

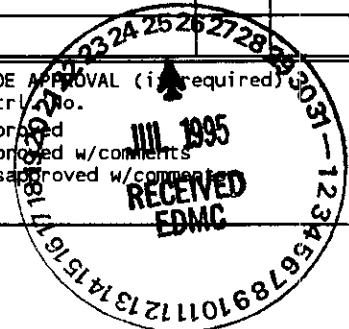
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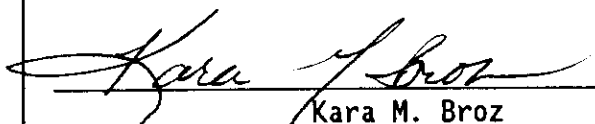
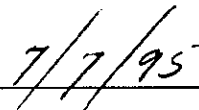
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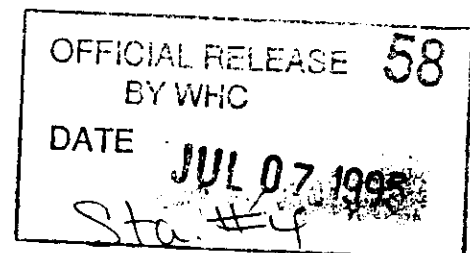
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7. Abstract

This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in tank 241-TY-106. This report supports the requirements of Tri-Party Agreement Milestone M-44-08.

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Tank Characterization Report for Single-Shell Tank 241-TY-106

J. Jo
Westinghouse Hanford Company

L. C. Amato
A. T. DiCenso
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Date Published
July 1995

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
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**Westinghouse
Hanford Company**

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EXECUTIVE SUMMARY

This tank characterization report summarizes the information on the historical uses, status, and the sampling and analysis results of the waste stored in the single-shell underground storage tank 241-TY-106. This report supports the requirement of the *Hanford Federal Facility Agreement and Consent Order*, milestone M-44-08 (Ecology et al. 1994).

Tank 241-TY-106 is one of six single-shell tanks located in the TY Tank Farm in the 200 West Area of the Hanford Site. The tank, which went into service in 1953 received mostly uranium recovery waste. When the tank was confirmed to be leaking in 1959, most of the supernate was removed. The tank now contains sludge from uranium recovery waste it received in 1953 to 1954 and diatomaceous earth what was added as a stabilizing agent in 1972.

Tank 241-TY-106 is currently classified as an assumed leaker. It has been interim stabilized, and intrusion prevention was completed in 1982. The tank is not on a Watch List and has no unreviewed safety questions associated with it.

A description and status of the tank are summarized in Table E-1, Table E-2, and Figure E-1. The tank, which has an operating capacity of 2,870 kiloliters (kL) or 758 kilogallons (kgal), contains 64 kL (17 kgal) of noncomplexed waste in the form of sludge.

Table E-1. Tank 241-TY-106.

TANK DESCRIPTION	
Type	Single-shell
Constructed	1952
In-service	1953
Diameter	23 m (75 ft)
Usable depth	7.0 m (23 ft)
Design capacity	2,870 kL (758 kgal)
Bottom shape	Dish
Ventilation	passive breather filter
TANK STATUS	
Total waste volume (January 1995)	64 kL (17 kgal)
Sludge volume (January 1995)	64 kL (17 kgal)
Surface level (January 1995)	34.6 cm (13.6 in.)
Temperature (1975 - 1994)	12.2 °C (54 °F) to 30 °C (86 °F)
Integrity	Assumed leaker
Watch List status	None
SAMPLING DATES	
Core samples	September 1985
Auger samples	March 1995
SERVICE STATUS	
Intrusion Prevention	1982
Not in service	

Notes:

cm = centimeters
 ft = feet
 in. = inches
 kgal = kilogallons
 kL = kiloliters

Table E-2. Single-Shell Tank 241-TY-106 Concentrations and Inventories for Major Analytes of Concern.

Physical Properties	Results	
Density ¹	1.37 g/mL	
Percent Water ²	34.7	
Heat Load ¹	89.8 Watts (306 Btu/hr)	
Chemical Constituents	Concentration	Inventory
Metals ¹	$\mu\text{g/g}$	kg
Al (Aluminum)	6,850	603
Fe (Iron)	45,800	4,030
Na (Sodium)	105,000	9,250
P (Phosphorus)	19,300	1,700
Si (Silicon)	89,300	7,870
U (Uranium)	8,250	727
Ions ¹	$\mu\text{g/g}$	kg
NO ₃ ⁻ (Nitrate)	170,000	15,000
NO ₂ ⁻ (Nitrite)	7,030	619
SO ₄ ²⁻ (Sulfate)	17,200	1,520
Organics ¹	$\mu\text{g C/g}$	kg C
Total Organic Carbon	2,290	202
Radionuclides	$\mu\text{Ci/g}$	Curies
¹³⁷ Cs ¹	21.9	1,930
⁹⁰ Sr ¹	136	12,000
Total Beta ¹	451	39,700
Total Alpha ¹	0.196	17.3
Total Alpha ²	0.0183	1.61

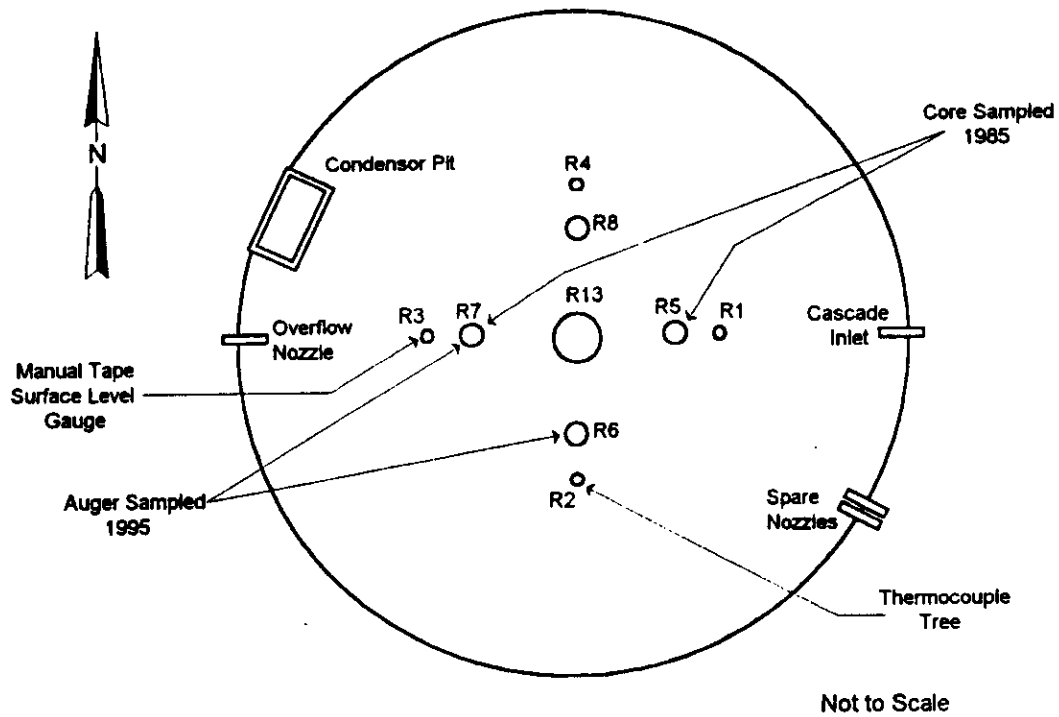
Notes:

¹Weiss, R. L. and B. M. Mauss, 1987, *Data Transmittal Package for 241-TY-106 Waste Tank Characterization*, SD-RE-TI-181, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

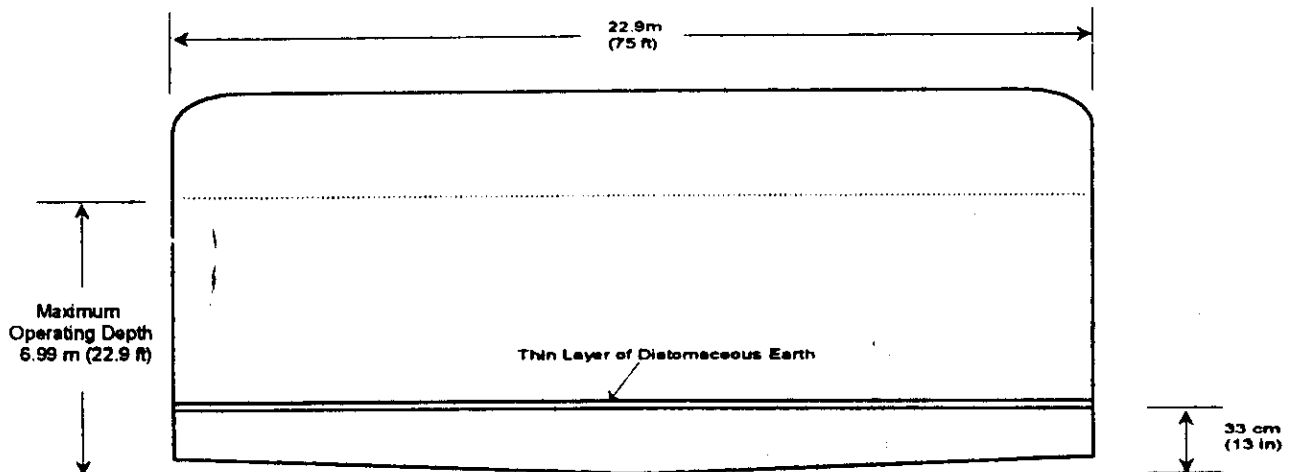
²Jo, J., 1995, *45-Day Safety Screening Results for Tank 241-TY-106, Auger Samples, 95-AUG-010 AND 95-AUG-011*, WHC-SD-WH-DP-102, Westinghouse Hanford Company, Richland, Washington.

Figure ES-1. Tank 241-TY-106.

Tank 241-TY-106



Waste Profile of Tank 241-TY-106



Total Tank Volume: 2,870 kL (758 kgal)
 Waste Volume (1/31/95): 64.3 kL (17 kgal)
 Sludge Volume (1/31/95): 64.3 kL (17 kgal)

This report summarizes two sampling and analysis events. Sludge composition and properties are based on two core samples taken from the tank in 1985 and two auger samples taken in March 1995. The data from the 1985 sampling event are considered to be highly representative of the waste currently because there have been no transfers to or from the tank since 1977. Because these samples were taken before the data quality objective (DQO) process was implemented, the resulting data do not fully satisfy the recent requirements for safety screening. The 1995 sampling samples were taken and analyzed in accordance with the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994).

The energetic behavior of the waste is quite low, as determined by differential scanning calorimetry (DSC) on the 1995 auger samples. They exhibited no exotherms. The total organic carbon (TOC) derived from the 1985 samples is 2,290 microgram of carbon per gram, which is approximately 0.2 percent wet weight or 0.4 percent dry weight. These concentrations are well below the 5 percent TOC (dry weight) criterion established by the organic safety program (Babad et al. 1994). The waste is estimated to be 30.3 percent to 39.2 percent water by weight, as determined by thermogravimetric analyses of the 1995 auger samples; and 55.5 percent based on the *Historical Tank Content Estimate for the Northwest Quadrant of the Hanford 200 West Areas* (Brevick et al. 1995). Both these percent water values are above the 17 percent criterion specified in the safety screening DQO. Based on results from the 1985 sampling event, the heat generated by the radioactivity in the tank is estimated to be 306 Btu/hr (89.8 watts) which is below the

40,000 Btu/hr (10,000 watts) criterion for a high-heat load tank classification. The temperature of the tank has ranged from 12.2 and 30 °C (54 and 86 °F) during the period from June 1975 to January 1995. The total alpha activity in the tank is less than 0.03 microcuries per gram, which is four orders of magnitude lower than the criticality safety criterion. Based on this information, the waste does not appear to have immediate safety concerns. This report does not include any tank head space vapor sampling and analysis information for evaluation.

The characteristics of tank 241-TY-106, physical properties, best estimates for the chemical and radiochemical composition, and the total tank inventory of the sludge in the tank are summarized in Table E-1 and Table E-2. These estimates are from 1995 and 1985 sampling events. The sludge contains high concentrations of iron, sodium, silicon, and uranium. Concentrations of nitrate and sulfate are also high. These results are consistent with the expected composition of the waste based on its history, which included transfers of uranium recovery waste and additions of diatomaceous earth (SiO₂).

REFERENCES

- Babad, H. and K. S. Redus, 1994, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Babad, H., S. M. Blacker, and K. S. Redus, 1994, *Data Quality Objective to Support Resolution of the Organic Fuel Rich Tank Safety Issue*, WHC-SD-WM-DQO-006, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Brevick, C. H., L. A. Gaddis, and L. A. Johnson, 1995, *Historical Tank Content Estimate for the Northwest Quadrant of the Hanford 200 West Areas*, ICF Kaiser Hanford Company, WHC-SD-WM-ER-351, ICF Kaiser Hanford Company, Richland, Washington.

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

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LIST OF TERMS

ANOVA	analysis of variance
DSC	differential scanning calorimetry
RPD	relative percent differences
SST	single-shell tank
TGA	thermogravimetric analysis
TOC	total organic carbon
TRAC	Track Radionuclide Components

1.0 INTRODUCTION

This tank characterization report overviews single-shell tank 241-TY-106 and its waste contents. It estimates concentrations and inventories for waste components based upon the latest sampling and analysis activities and background tank information. The results of the two most recent sampling events associated with Tank 241-TY-106 are presented. In March 1995, two auger samples were taken for analysis in accordance with the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994). In 1985, an attempt was made to take seven core samples from Tank 241-TY-106 in 1985; however, a quantity of waste sufficient for analysis was obtained from only two of these cores.

Tank 241-TY-106 was filled to near capacity in 1954 with uranium recovery waste; no more transfers occurred until 1959. In 1959, it was discovered that the tank was leaking and supernatant waste was pumped to other tanks in the 241-TY Tank Farm. From 1959 to 1972, no transfer activities were conducted. In 1972, diatomaceous earth was added to the tank to stabilize any remaining liquid. The tank is no longer in active service and presently contains sludge left behind by the uranium recovery waste. The diatomaceous earth most likely exists as a thin layer covering the sludge. The concentration and inventory estimates reported in this document reflect the current composition of the waste based upon available data. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order*, milestone M-44-08 (Ecology et al. 1994).

1.1 PURPOSE

The purpose of this report is to summarize the information about the use and contents of tank 241-TY-106. When possible, this information will be used to assess issues associated with safety, operations, environmental, and process development activities. This report is also a reference point for more detailed information about Tank 241-TY-106.

1.2 SCOPE

The 1985 core samples were taken as part of the development testing of sampling equipment designed to take full-depth samples (cores) from single-shell tanks (SSTs). Following extended testing with simulated SST waste, initial testing and application of the equipment to actual SST waste was undertaken in the 241-TY Tank Farm. The 241-TY Tank Farm also was sampled to provide waste characterization to support the proposed dome-fill test. This was based on the idea of filling SSTs with suitable material to minimize the effects of eventual dome collapse (Weiss 1986). The samples were analyzed for metals, anions, and radiochemical constituents.

The auger samples taken in 1995 were obtained in accordance with the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994). Sampling and analysis activities are focused on either verification of the non-Watch List tank status or identification of any unknown safety issues associated with the tank.

This report does not include any information on vapor space sampling and analysis to determine the composition of the tank head space gases.

2.0 HISTORICAL TANK INFORMATION

Tank 241-TY-106 is not in active service, and its present waste volume is not expected to change. The most current volume status of the tank is provided in routinely updated reports. Tank history includes tank design information, waste transfer history, waste temperature, and level surveillance data.

2.1 TANK STATUS

According to Hanlon (1995), tank 241-TY-106 contains 64.3 kiloliters (kL) or 17 kilogallons (kgal) of noncomplexed waste. The waste depth is approximately 34.6 centimeters (cm) or 13.6 inches (in.) with reference to the bottom of the tank. The tank waste consists of sludge and contains no salt cake or drainable liquid. Tank 241-TY-106 entered service in 1953 and stored uranium recovery waste. After the tank was confirmed to be leaking in 1959, most of the supernatant waste was pumped out, and the tank was removed from service. Diatomaceous earth was added to the tank in 1972 to stabilize any remaining supernate. Because efforts were taken to minimize the amount of liquid waste, the tank is reported to be *interim stabilized* and is classified as an *assumed leaker*. *Intrusion prevention* was completed in 1982. The tank is not on any Watch List, and there are *no unreviewed safety questions* associated with it. The average in-tank temperature on January 1, 1995, was 16.1 °C (61 °F) which most likely, is the temperature for the vapor space. The tank is ventilated with a passive breather filter (WHC 1994).

2.2 TANK DESIGN

Tank 241-TY-106 is one of six 2,870 kL (758 kgal) tanks that comprise the TY Tank Farm located in the north half of the 200 West Area at the Hanford Site (see Figure 2-1). Construction of this tank farm was completed in 1952. For more information about the TY Tank Farm and single-shell tanks, refer to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994). These tanks are similar to the original Hanford Site waste tanks (built in the mid-1940s) except they are deeper and have larger capacities. The tanks have dished bottoms and are arranged in three cascades of two tanks each. Each cascade of two tanks is connected to the next cascade by pipes in a step series. When the first tank in a cascade became full, waste would flow to the next tank. Tank 241-TY-106 is the second tank in a cascade with tank 241-TY-105.

Tank 241-TY-106 is a single-shell tank consisting of a carbon-steel liner within a reinforced-concrete shell and dome. It has a diameter of 22.9 meters (m) or 75 feet (ft) and a depth of about 7.02 m (23 ft) (Welty 1988). Figure 2-2 shows the basic design of tank 241-TY-106. Instruments, which enter the tank through risers, monitor the temperature and liquid level. Figure 2-3 shows the position of these risers. The waste surface level within the tank is measured with a manual tape device. Waste entered the tank through a

Figure 2-1. Location of the TY Tank Farm.

200 West Area and TY Tank Farm Location

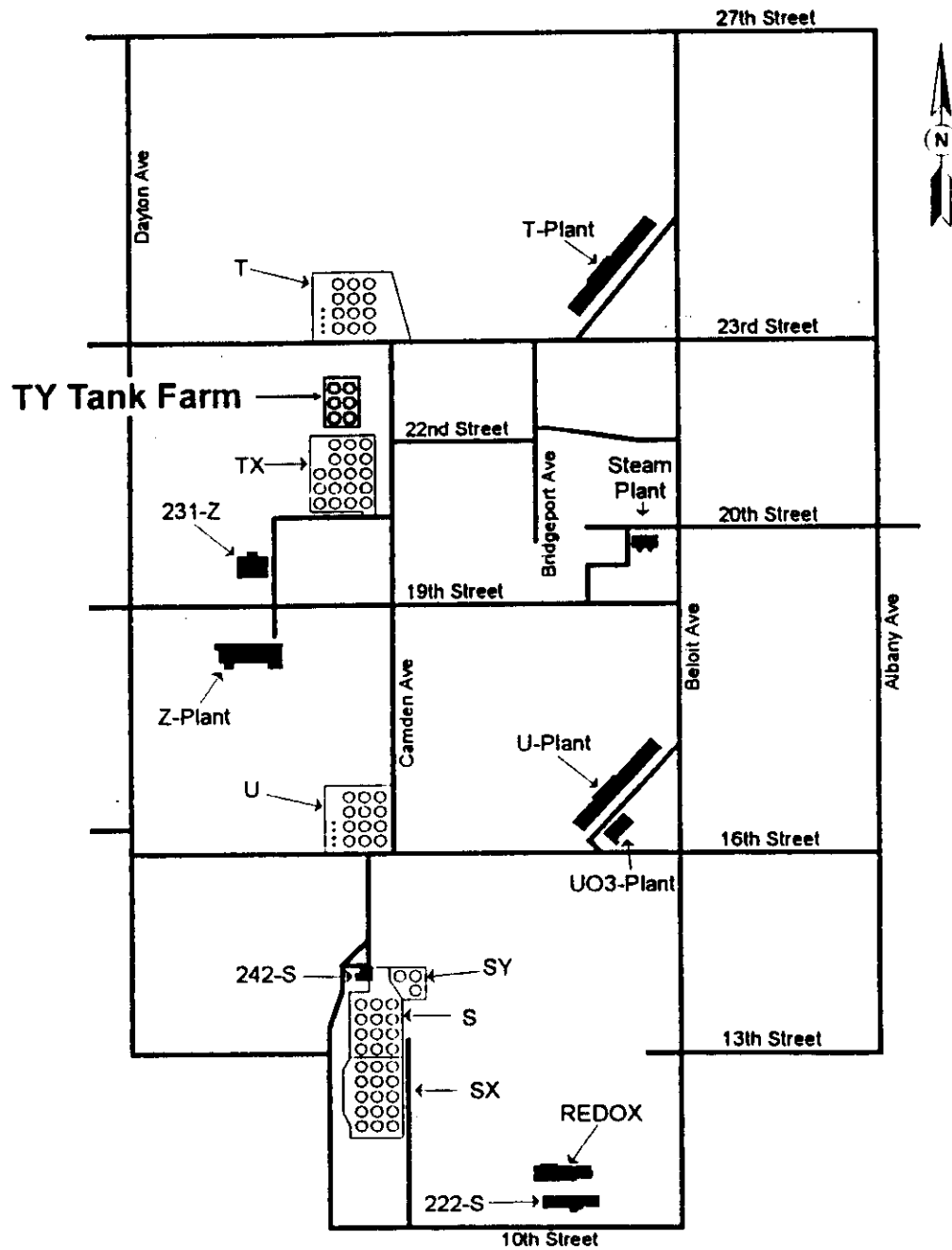


Figure 2-2. Basic Tank Design.

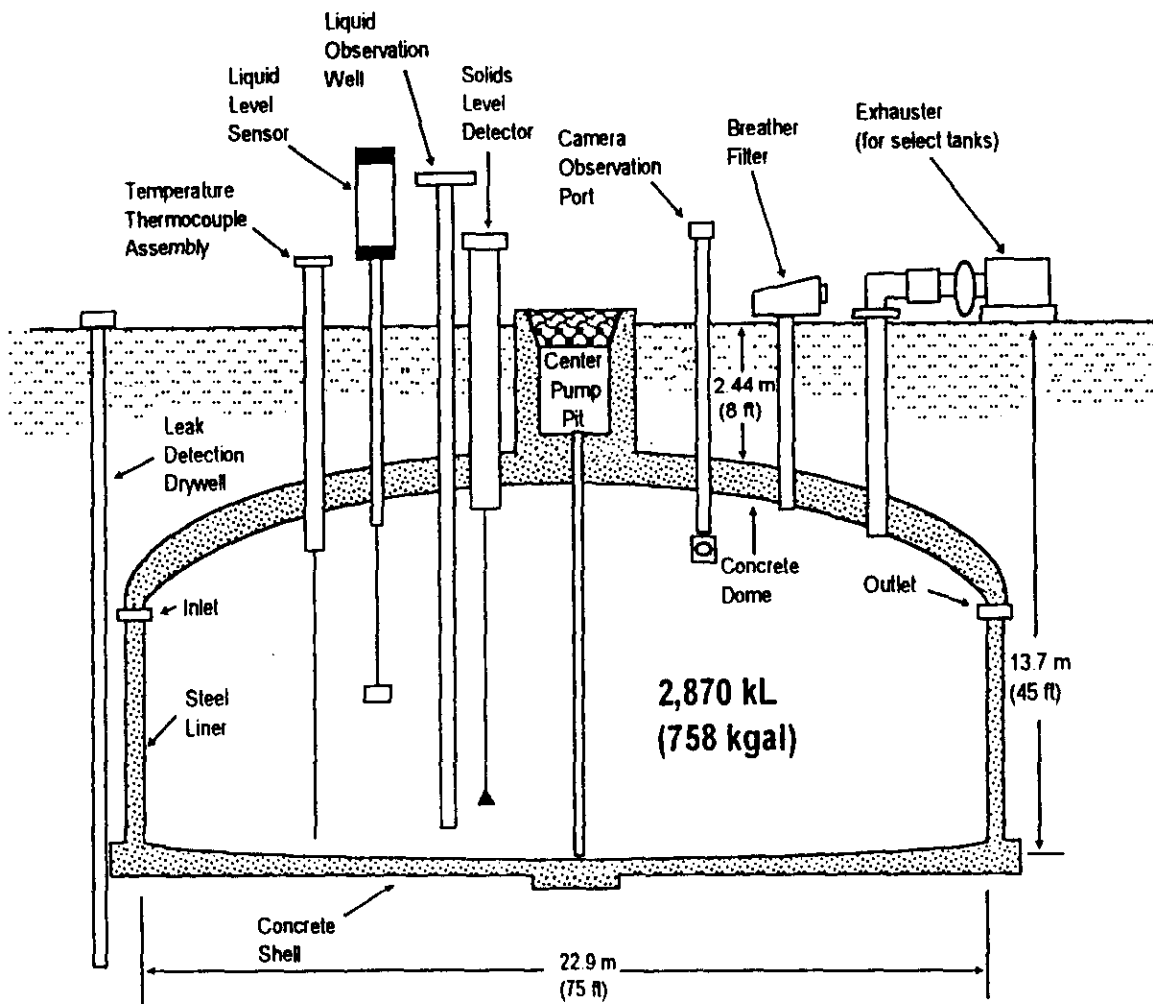
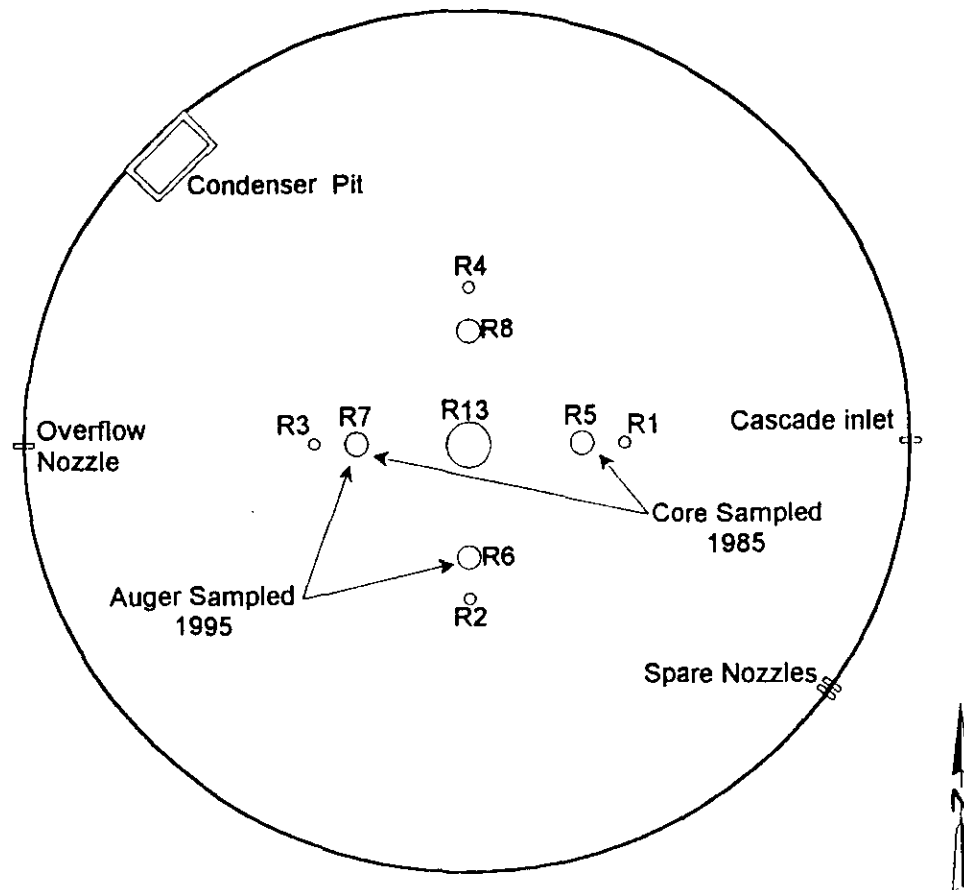
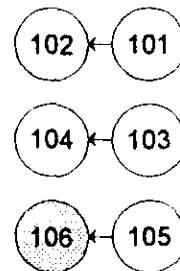
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Figure 2-3. Tank 241-TY-106 Riser Configuration.



No.	Dia.	Description
R1	4"	Breather Filter
R2	4"	Temperature Tree
R3	4"	Surface Level Manual Tape
R4	4"	Spare
R5	12"	Spare
R6	12"	Spare
R7	12"	Observation Port
R8	12"	Spare
R13	42"	Concrete Plug

241-TY Tank Farm



Sources:
 Alstad 1993
 Vitro Engineering 1985

cascade inlet in the tank sidewall from tank 241-TY-105. Tank 241-TY-106 was also equipped with an overflow outlet located in the tank wall opposite the cascade inlet and about 7.18 m (283 in.) above the tank floor.

Five external drywells, which are located near tank 241-TY-106, are the tanks primary means of leak detection. Elevated activity levels were measured in four wells prior to 1990, but current readings are below the 50-counts-per-second level (Welty 1988; Brevick, Gaddis, and Johnson 1995), indicating no leaks in the tank.

2.3 PROCESS KNOWLEDGE

Most process history documents indicate the tank received only uranium recovery waste while the tank was active. However, according to Agnew et al. (1994), a significant amount of the waste transferred to the tank was of an unknown origin and is hypothesized to be a part of the lag storage space used in the 242-T-Evaporator. Most of the supernate was removed from the tank in 1959 after it was confirmed to be leaking. The tank now contains sludge from the waste it received in 1953 and 1954 and diatomaceous earth that was added as a stabilizing agent in 1972. The estimated amounts of waste added and removed from the tank are summarized in Table 2-1. The fill history of this tank is shown in Figure 2-4.

2.3.1 Waste Transfer History

Tank 241-TY-106 went into service in June 1953 receiving uranium recovery waste through the cascade inlet from Tank 241-TY-105 (Anderson 1990; Jungfleisch 1984; and Agnew et al. 1994). Uranium recovery waste resulted from the tributyl phosphate uranium extraction process employed at U Plant in the 1950s. Metal waste sludge, which originated from uranium fuel dissolution in the bismuth phosphate process, was sluiced from waste storage tanks, and the uranium in the waste was separated from fission products using a process based on tributyl phosphate. The estimated composition of sludge from uranium recovery waste is shown in Table 2-2. According to Anderson and Jungfleisch, tank 241-TY-106 received a total of nearly 20,070 kL (5,300 kgal) of this waste during 1953 and 1954. Through the third quarter of 1954, most of the waste was transferred periodically to tank 241-TX-118 for concentration in the 242-T Evaporator. In late 1954, the tank was filled to near capacity, and there were no further transfers until 1959. Agnew et al. (1994) differs from Anderson (1990) and Jungfleisch (1984) in the amount of waste directed to the tank (see Table 2-1) and designates 3,670 kL (969 kgal) of the waste as unknown. The sludge layer currently remaining in the tank could have accumulated in the bottom at this time.

Table 2-1. Tank 241-TY-106 Process History Summary.

Waste Type ^{1,2}	Amount Received kL (years)	Amount Removed kL (years)	Waste Type ³	Amount Received kL (years)	Waste Remaining in Tank kL
Uranium recovery	20,070 (1953, 1954)	20,036 (1959)	Uranium recovery	16,900 (1953, 1954)	15
Diatomaceous earth	30 (1972)	0	Unknown	3,670 (1954)	45
			Diatomaceous earth	30 (1972)	4

Notes:

¹Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

²Jungfleisch, F. M., 1984, *TRAC: Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, SD-WM-TI-057, Rockwell Hanford Operations, Richland, Washington.

³Agnew, S. F., P. Baca, R. Corbin, T. Duran, and K. Jurgensen, 1994, *Waste Status and Transaction Record Summary for the Northwest Quadrant*, WHC-SD-WM-TI-699, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

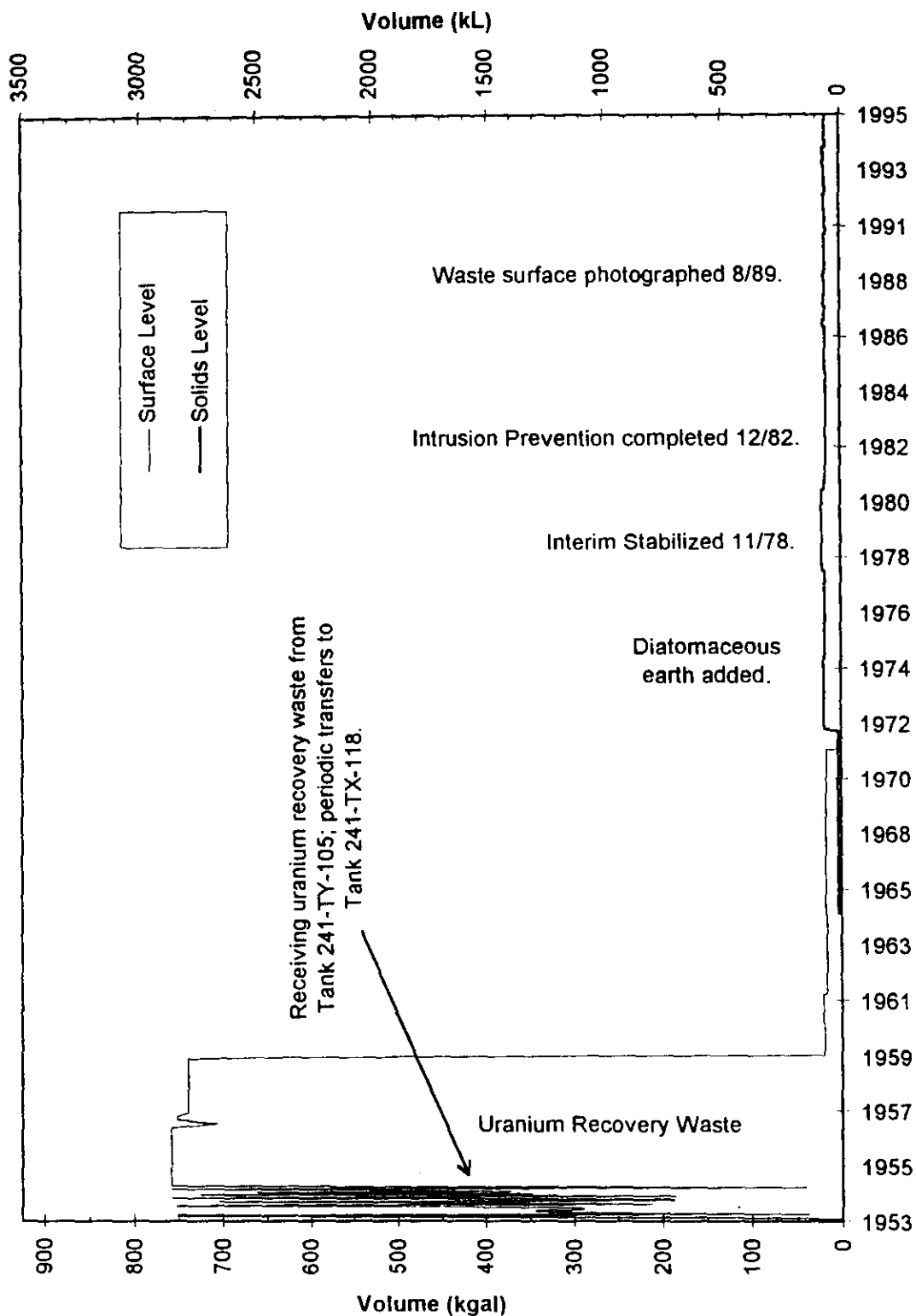
Table 2-2. Uranium Recovery Waste Predicted Sludge Composition¹.

Chemical Constituents	$\mu\text{g/g}$
Na	8.45E+04
Fe	8.53E+04
OH ⁻	9.92E+04
NO ₃ ⁻	6.50E+04
CO ₃ ²⁻	4.36E+03
PO ₄ ²⁻	4.48E+03
SO ₄ ²⁻	1.12E+05
Cl ⁻	2.96E+02
U	4.99E+04
Radiological Constituents	$\mu\text{Ci/g}$
^{239,240} Pu	1.80E-03
¹³⁷ Cs	6.11
⁹⁰ Sr	1.88E+02

Notes:

Agnew, S. F., 1995, *Hanford Defined Wastes: Chemical and Radionuclide Compositions*, LA-UR-94-2657, Rev. .5, Los Alamos National Laboratory, Los Alamos, New Mexico.

Figure 2-4. Tank 241-TY-106 Fill History.



Tank 241-TY-106 was first suspected of leaking in 1959 (Bergmann 1991). During the third quarter, the tank was classified as a *confirmed leaker* (this classification later became *assumed leaker*) and most of the supernatant waste was pumped to other tanks in the TY Tank Farm. Updated estimates indicate about 76 kL (20 kgal) of waste leaked from the tank (Hanlon 1995).

In 1972, 27 tons of diatomaceous earth (SiO_2) were added to the tank to stabilize any remaining liquid waste (Brevick et al. 1995). Anderson indicates more desiccant was added to the tank in 1977; however, the substance and the amount were not specified. There were no further additions to, nor transfers out of, the tank. Based on Anderson (1990) and Jungfleisch (1984), the waste remaining in the tank is expected to consist of uranium recovery waste sludge covered by diatomaceous earth. According to Agnew et al. (1994), the waste is expected to consist of sludge mostly from the unknown waste added to the tank in 1954 and, to a lesser extent, sludge from uranium recovery waste and diatomaceous earth.

2.3.2 Historical Estimate of Tank 241-TY-106 Contents

A preliminary estimate of the waste constituents of Tank 241-TY-106 can be developed from historical transfer and process records. Two models developed to predict the chemical content of Hanford Site waste tanks are the Historical Tank Content Model (Brevick et al. 1995) and the Track Radionuclide Components Model (TRAC) (Jungfleisch 1984).

The Historical Tank Content Model was developed at Los Alamos National Laboratory; its predictions are shown in Table 2-3. These historical tank content estimates use waste transfer summaries (Agnew et al. 1994) to estimate the volume of each waste type currently stored in each Hanford Site waste tank. The volume data are combined with waste stream chemistry information (Agnew 1995) to predict waste layering and to estimate the composition in a specific tank. The accuracy of the Historical Tank Content Model depends upon the completeness and accuracy of transfer history information. For tank 241-TY-106, the model states that 70 percent of the present tank contents are unknown; even so, the historical tank content estimates for this tank compare favorably with the predicted composition of uranium recovery sludge.

The Track Radionuclide Components Model (Jungfleisch 1984) simulated the Hanford Site waste management system and predicted selected waste constituent inventories for each tank by performing a mass balance. Historical records from production and treatment facilities; a waste transaction record of intra-tank transfers; and models simulating the operation of reactors, chemical processes, and waste management through 1980 were the basis of the project. The input data, computer code, and resultant waste composition predictions have not been verified or validated. Special circumstances encountered in a localized area may not have been incorporated into the TRAC model. The TRAC predictions for chemical and radionuclide inventories for tank 241-TY-106 are also shown in Table 2-3.

Based on the tank's process history, the waste remaining in the tank is proposed to consist of solids, which settled from the uranium recovery waste transferred to the tank during 1953 and 1954, and a layer of diatomaceous earth (SiO_2) that was placed on top of the sludge in 1972. Significant components expected from uranium recovery waste include uranium, sodium, iron, hydroxide, nitrate, carbonate, and sulfate. The waste would contain very little aluminum. The radionuclides expected in large amounts are ^{90}Sr , since it would precipitate as the hydroxide salt, and to a lesser extent, ^{137}Cs . The tank would not contain ferrocyanide or significant amounts of organic complexants or transuranics.

Table 2-3. Tank 241-TY-106 Historical Tank Contents Estimate.¹

Physical Properties		Historical Tank Content Estimate Result		
Bulk Density		1.42 g/cc		
Water wt%		55.5		
Heat Load		2.27E-03 kw (7.74 Btu/hr)		
Chemical Constituents	Historical Tank Content Estimate		Track Components	
	$\mu\text{g/g}$	kg	$\mu\text{g/g}$	kg
Al	—	—	1.03E+01	8.90E-01
Ca	4.85E+03	4.17E+02	—	—
Cl^{-1}	1.86E+03	1.60E+02	8.24E-13	7.09E-14
CO_3^{-2}	1.28E+04	1.10E+03	6.98E+03	6.00E+02
Cr	2.10E+02	1.81E+01	1.21E-24	1.04E-25
Fe	9.56E+04	8.22E+03	3.24E-01	2.79E-03
Na	7.49E+04	6.44E+03	2.67E+05	2.30E+04
Ni	3.32E+03	2.86E+02	—	—
NO_3^{-1}	9.02E+04	7.75E+03	5.77E-03	4.96E-04
OH^{-1}	9.94E+04	8.54E+03	7.91E+02	6.80E+01
PO_4^{-3}	6.24E+03	5.36E+02	1.10E-03	9.50E-05
SO_4^{-2}	6.61E+04	5.68E+03	2.23	1.92E-01
U	2.34E+04	2.01E+03	1.95E+04	1.68E+03

Radiological Constituents	Historical Tank Content Estimate		Track Radionuclide Components	
	$\mu\text{Ci/g}$	Ci	$\mu\text{Ci/g}$	Ci
²⁴¹ Am	—	—	3.49E-02	3.00
¹³⁷ Cs	0.639	54.9	2.32E-06	2.00E-04
Pu	2.32E-03	3.32E-03 (kg)	—	—
²³⁸ Pu	—	—	6.98E-04	6.00E-02
²³⁹ Pu	—	—	9.30E-02	8.00
²⁴⁰ Pu	—	—	1.05E-02	9.00E-01
²⁴¹ Pu	—	—	4.65E-02	4.00
⁹⁰ Sr	3.47	298	1.16E+02	1.00E+04

Notes:

¹Brevick, C. H., L. A. Gaddis, and L. A. Johnson, 1995, *Historical Tank Content Estimate for the Northwest Quadrant of the Hanford 200 West Areas*, ICF Kaiser Hanford Company, WHC-SD-WM-ER-351, ICF Kaiser Hanford Company, Richland, Washington.

Jungfleisch, F. M., 1984, *TRAC: Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, SD-WM-TI-057, Rockwell Hanford Operations, Richland, Washington.

2.4 SURVEILLANCE INFORMATION

2.4.1 Surface Level Readings

The waste surface level within tank 241-TY-106 is measured with a manual tape device through riser 3 (see Figure 2-3). Surface level measurements are taken quarterly and put into the Computer Automated Surveillance System. The manual gauge consists of a reel-mounted calibrated steel tape attached to an electrically conductive plummet (Johnson 1995). Normally, the plummet is lowered until it contacts the conductive surface of the waste completing the electrical circuit. However, in tanks with dry, nonconductive waste surfaces, such as the surface found in tank 241-TY-106, measurements are made by lowering the plummet until the tape goes slack indicating contact with the surface has been established. A measurement precision of $\pm \frac{1}{2}$ in. has been established for manual tapes measuring a liquid surface. Measurement precision has not been determined for manual tapes measuring nonconductive surfaces; however, these measurements are subjective and are expected to be less precise.

A measurement of 33 cm (13 in.) relative to the bottom of the dish was recorded January 1, 1995. Quarterly readings from 1981 to 1994 are shown in Figure 2-5; the measurements from this period show a stable surface level.

2.4.2 Internal Tank Temperatures

Fourteen thermocouples, assembled in a thermocouple tree entering the tank at riser 2, monitor temperatures within tank 241-TY-106 (Tran 1993). Temperature measurements for this tank are recorded semiannually. Specific thermocouple elevations are not available for this tank; however, the thermocouple with the lowest number is generally the lowest thermocouple in a particular tree. Neither the specific type of thermocouples employed in this tank, nor thermocouple condition, are available. Thermocouple error can vary depending upon the type and installation; average error can vary from ± 1 to 3 °C, while maximum error can vary from ± 1.5 to 12 °C (Scaief 1991).

Temperature information for tank 241-TY-106 is available from the Surveillance Analysis Computer System database from June 1975 to January 1995. Except for a few apparent gaps in the data, a minimum of two data points from thermocouples 1-4 are available for each year; data was available from thermocouples 1-12 from 1975 to 1977 and from thermocouples 1-14 from 1982 to 1985. Maximum temperature readings for specific dates and averages of all available readings on those dates are plotted in Figure 2-6. The highest in-tank temperature recorded during this time was 30 °C (86 °F) at thermocouples 1-9 on August 11, 1977; the lowest temperature, which is not plotted, was 12.2 °C (54 °F) recorded at thermocouples 3 and 4 on April 13, 1977. These temperatures are within design limits of the tank. The average in-tank temperature for the period was 18.7 °C (65.6 °F).

Figure 2-5. Tank 241-TY-106 Quarterly Surface Level Measurements: 1981 to 1995.

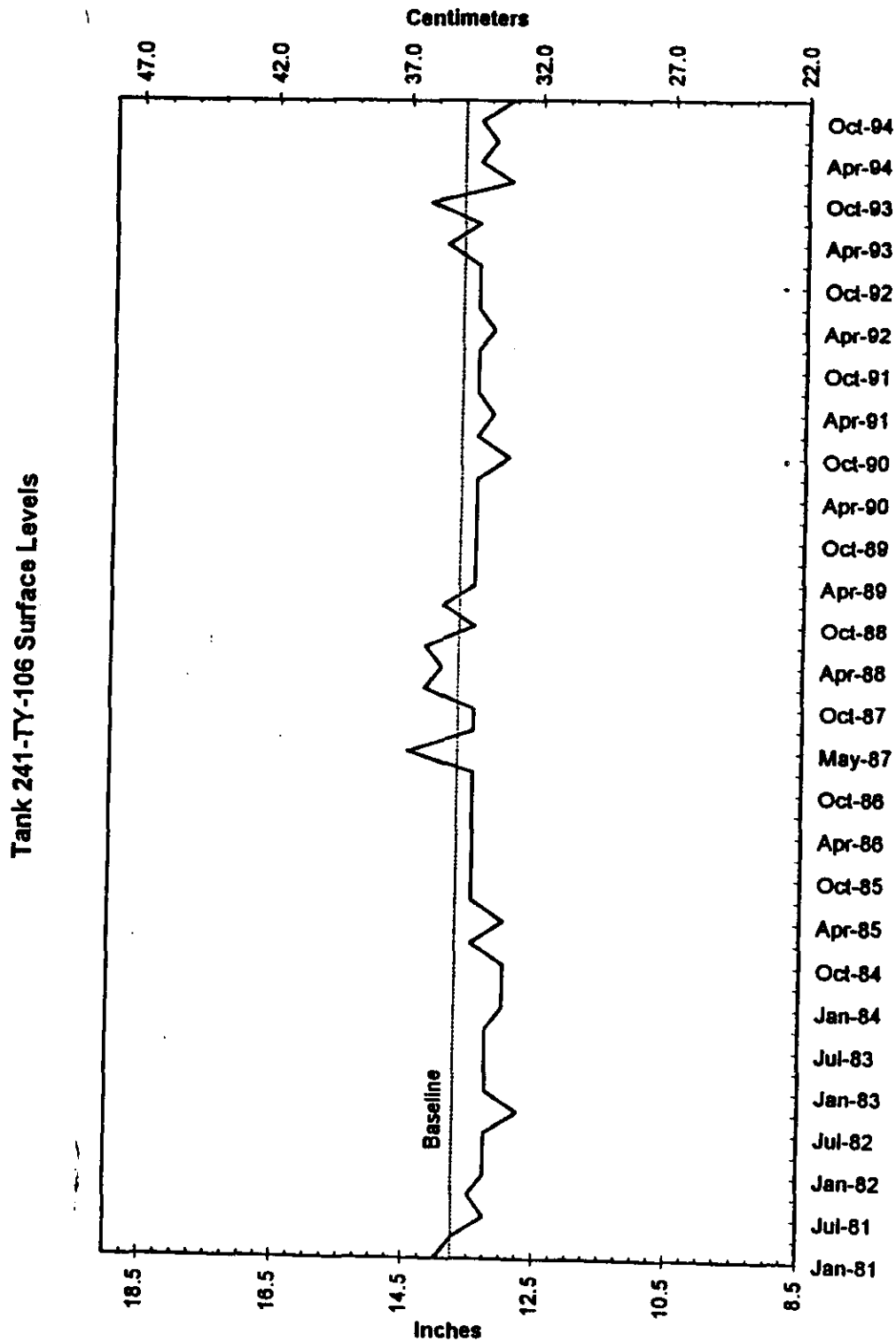
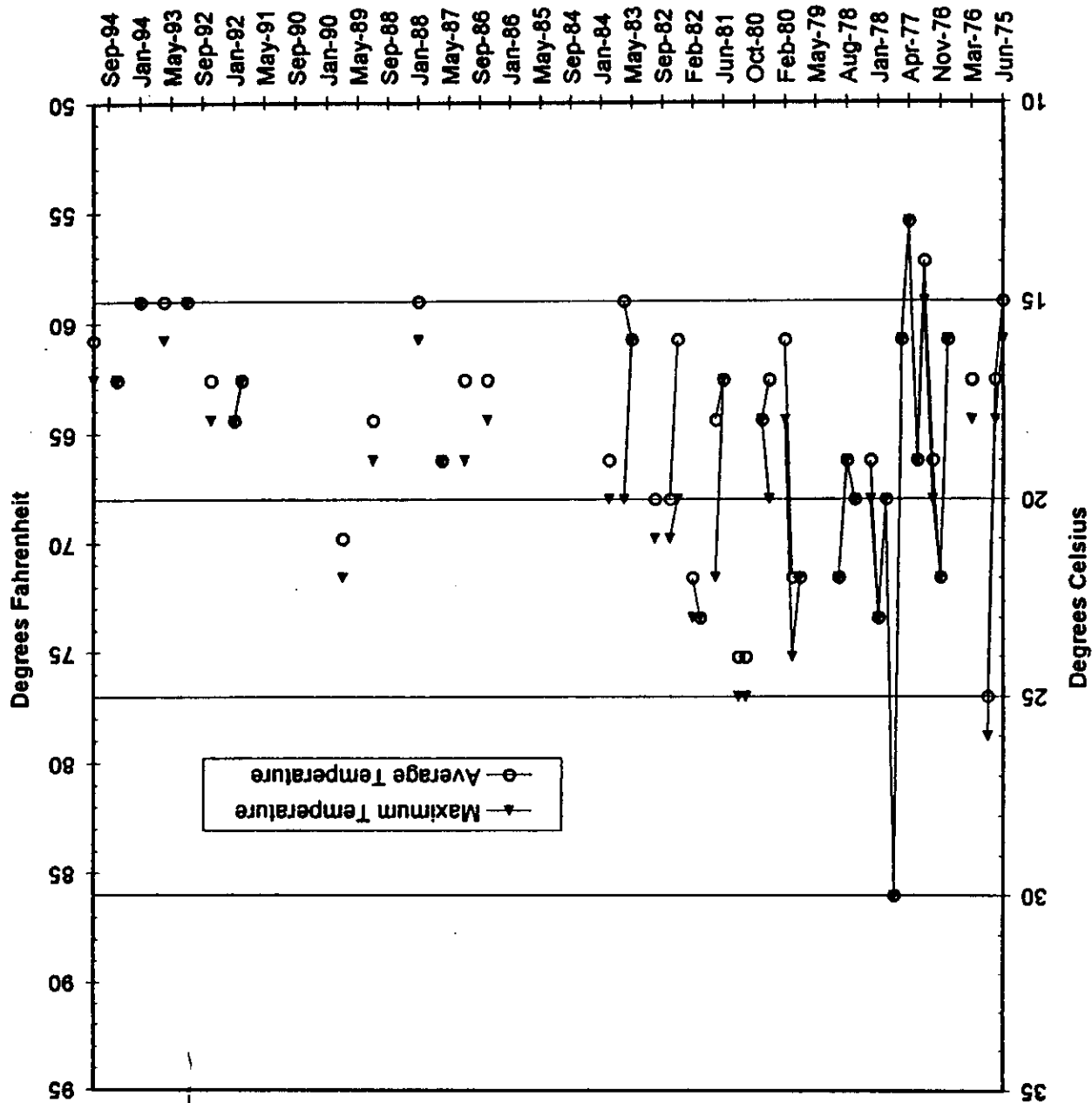


Figure 2-6. Tank 241-TY-106 In-Tank Temperatures.



There appears to be little change in average temperatures over the time period (Brevick, Gaddis, and Johnson 1995). Cyclical changes, which appear to be seasonal, are observed.

2.4.3 In-Tank Photographs

The interior of tank 241-TY-106 was most recently photographed on August 22, 1989. A montage of these photographs shows a dry and cracked waste surface with no liquid visible. The diatomaceous earth added to this tank in the 1970s appears to be spread uniformly over the entire tank surface (Brevick, Gaddis, and Johnson 1995). Brown surface stains can be seen near the center of the tank; a discarded manual tape, some gasket parts, and other debris can also be seen lying on the surface. A temperature probe, manual tape, condenser pit riser, and some nozzles were identified and labeled. The montage should be an accurate representation of current tank contents because there has been no activity (except for the 1995 auger sampling) in the tank since the photographs were taken.

3.0 TANK SAMPLING OVERVIEW

This section describes the two sampling and analysis events associated with tank 241-TY-106. The most recent sampling event took place in early March 1995 when two auger samples were taken and analyzed in accordance with the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994) and the *Tank 241-TY-106 Characterization Plan* (Schreiber 1995). Two core samples were taken from the tank in 1985, and the waste material was analyzed for chemical and radiological constituents.

3.1 DESCRIPTION OF SAMPLING EVENT (1995)

Two samples were taken from the tank by using a 20-inch auger. The first auger sample was removed from riser 6 (sample # 95-AUG-011) on March 2, 1995 and consisted of 84.55 grams of sample. No drainable or liner liquid was recovered, and most of the sample was contained on flutes 11 through 19. The second auger sample was removed from riser 7 (sample # 95-AUG-010) on March 3, 1995 and consisted of 68.97 grams of sample. No drainable or liner liquid was recovered, and most of the sample was contained on flutes 17 through 10, with a thin coating of what appeared to be the same material on the outside of flutes 1 through 16. The drill string dose rate for riser 6 was 250 milliroentgens per hour (mR/hr) and for riser 7 the dose rate was 175 mR/hr. Recoveries were less than 100 percent; otherwise, no problems related to the sampling event were noted. The auger has 19 flutes with flute 1 being located at the shaft and flute 19 at the tip.

3.1.1 Sample Handling (1995)

The two samples were received at the 222-S laboratory on March 3, 1995; extrusion took place on March 8, 1995. Photographs were taken of the extrusion but were not provided with the data package. The subsampling scheme and visual observations of the samples are given in Table 3-1. The material from riser 6 was split into upper and lower subsamples based on an observed change in the color of the waste. The three subsamples were homogenized prior to analysis. Each subsample was analyzed for differential scanning calorimetry (DSC), percent water, and total alpha. A flow diagram of the entire process is shown in Figure 3-1.

Table 3-1. Subsampling Scheme and Description.

Sample Identification	Location	Sample Description	
S95T000299 & S95T000302	Riser 6, flutes 11-13 (upper half)	light olive green in color	Overall, these subsamples were very moist and runny with a soft paste-like consistency
S95T000301 & S95T000303	Riser 6, flutes 14-19 (lower half)	mixture of olive green and light brown	
S95T000286 & S95T000288	Riser 7, flutes 17-19 (entire sample)	medium brown in color and very sticky with a paste-like consistency, although some of the sample was drier and not as sticky	

3.1.2 Sample Analysis (1995)

The only analyses conducted on the two auger samples were DSC, thermogravimetric analysis (TGA), and total alpha, in accordance with the tank characterization plan (Schreiber 1995). The TGA precision between the sample and duplicate for sample S95T000299 exceeded the quality control criteria and was rerun with a result of 34.6 percent. This compared well with the original results of 37.2 and 32.2 percent. Both spikes for total alpha from the riser 6 subsamples were slightly below the quality control criterion, indicating there may be a low bias in the data results. No other problems were noted. The results of the analyses are provided in Sections 4.2 and 4.3.

3.2 DESCRIPTION OF SAMPLING EVENT (1985)

Between July 18, 1985 and September 26, 1985, seven core segments were taken from tank 241-TY-106. One objective for the sampling events was to develop techniques that would ensure the successful acquisition of full-depth core samples. Therefore, both rotary and push mode core sampling methods were attempted. All push mode samples taken from risers 5 and 7 exhibited 0 percent recovery. Rotary mode sampling proved to be more productive. Table 3-2 summarizes each sampling event.

The waste obtained for analysis from riser 5 was contacted at 12 inches above the calculated tank bottom, and a fairly hard layer was entered at 6 inches above the bottom. Seven inches of water were used for hydrostatic head fluid, and the sampler read 30 mrad through the drill string (Weiss and Mauss 1987).

Figure 3-1. Laboratory Sample Handling Flow Chart for Tank 241-TY-106.

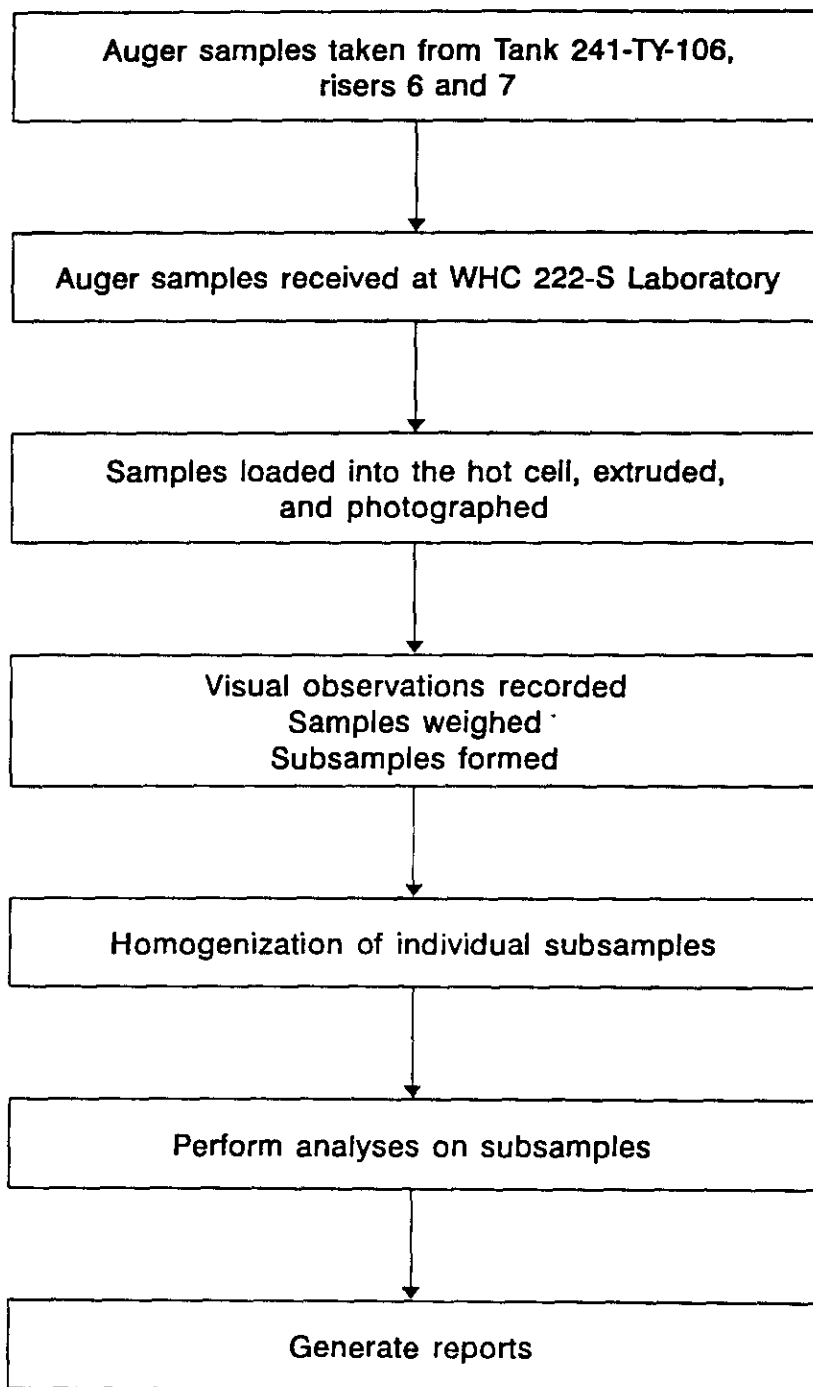


Table 3-2. Tank Sampling Observations¹.

Core	Date	Riser	Mode of Sampling	Percent Recovery	Comments
1	7/18/85	R-5	Push	0	The quadralatch may not have latched.
2	7/24/85	R-5	Push	0	Discovered waste was harder than expected. Rotary mode sampling requested.
3	7/31/85	R-5	Rotary	50	12-inch segment was expected; 6-inch segment was obtained.
4	7/31/85	R-5	Rotary	0	Drill string was caught in material in the tank and was twisted off.
5	9/23/85	R-7	Push	0	The expected sample recovery was 10.25 inches. Insufficient sample was recovered for analysis.
6	9/24/85	R-7	Push	0	The sampler was lowered to the waste level before the grapple was connected to the pintel.
7	9/26/85	R-7	Rotary	47	12.75-inch segment was expected, 6-inch segment was obtained.

Note:

¹Weiss, R. L. and B. M. Mauss, 1987, *Data Transmittal Package for 241-TY-106 Waste Tank Characterization*, SD-RE-TI-181, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

The waste taken for analysis from riser 7 was contacted at 15.25 inches above the predetermined tank bottom, and a very hard layer was encountered at 5 inches from the contacted bottom. The pintel unscrewed from the rod, and the drill string had to be pulled to retrieve the sampler. The drill string dose rate was 50 mrads on contact. There was no mention of the use of hydrostatic head fluid. The percent recoveries were calculated based on the length of the waste expected with respect to the length of waste actually recovered.

3.2.1 Sample Handling (1985)

Segments were received at the Westinghouse Hanford Company 222-S Laboratory then extruded in a shielded hot cell. After extrusion, each segment was weighed, photographed, and measured while still in the hot cell. Portions were packaged for removal to an open-faced hood for analytical sample preparation. The breakdown of the segments and their sample identification are shown in Table 3-2. Core 4 is not listed in Table 3-3 since the drill string, core barrel, and sampler were left in the tank.

3.2.2 Sample Analysis (1985)

After the segments were extruded, the two segments that had a sufficient amount of sample for analysis (samples 111C and 161C) were washed with water, centrifuged, and the water was analyzed for a set of water soluble analytes. The leftover sludge was then treated with a 5 M HCl acid solution, centrifuged, and the leachate was analyzed for chemical and radiochemical constituents. Any material not dissolved by the acid was combined with an HCl-HNO₃-HF solution at elevated temperatures in a pressure reactor before the remaining analytes were identified. For samples with large amounts of acid insoluble solid, only a portion of the material was used for the pressure dissolution (0.5 load limit of the reactor) (Weiss and Mauss 1987).

Table A-1 gives a list and the results of the analytes requested for tank 241-TY-106. As a note, sample 161C was tested for only two anions; sample 111C was tested for seven anions.

All separable liquids from the segments in each core were combined to form the drainable liquid fraction. Many samplers contained some of the hydrocarbon fluid used to maintain the hydrostatic head in the drill string during sampler changing. This organic was separated from the aqueous drainable liquid portion and was not analyzed. In general, a minimum of 25 milliliters of drainable liquid was required from each core for complete analysis. Solid characterization could be performed on as little as 5 g of material (Weiss 1986). Analyses on drainable liquids were not done for tank 241-TY-106 because of an insufficient amount of sample.

Core composites were made by blending segment portions based on weight percent fractions of the total recovered core weight. Individual segments were homogenized as much as possible before fractions were taken for the composite. Originally, analyses were scheduled for individual segment solid phases, segment composites, and core composites. This was later changed to analyses of core composite samples only.

Table 3-3. Segment Breakdown for Tank 241-TY-106¹.

Core	ID Number	Subsample ID	Matrix	Description
1	111	NA	NA	Insufficient sample for analysis. A very small amount of waste was stuck to the sampler bottom. The white and brown waste resembled diatomaceous earth.
2	121	NA	NA	Insufficient sample for analysis. A small amount of material was stuck to the sampler bottom. It was a white, yellow, crumbly solid with brown flecks.
3	131	NA	solid	The sample was very soft at the bottom, grading to quite firm at the top. Two distinct solid phases were discernible. The top portion appeared gray in the hot cell. When removed, it was light brown, dry, and flaky. The bottom portion was dark reddish brown and "mushy." Some "chunks" were noted in the bottom portion.
3	NA	111D	drainable liquid	Insufficient sample for complete analysis. A light yellow aqueous solution.
3	NA	111C	core composite	The extrusion was split lengthwise, and one side was blended for the composite. A smooth, medium brown material with small chunks resulted.
5	141	NA	solid	Insufficient sample for analysis. The sample was grayish and hard with what appeared to be a brown leaf imbedded in it.
6	151	NA	solid	Insufficient sample for analysis. Similar material to sample number 141.
7	161	NA	solid	The waste appeared very similar to sample number 131: top portion gray, bottom brownish. The phases were more smeared together than in sample 131. The two solid phases were not separated. When removed from the hot cell, the gray portion appeared light brown in color and was dry. The lower portion appeared brown with black flecks in it. One 5/8 inch by 1/2 inch dark gray "rock" was removed from the lower section (4.7 g).
7	NA	161C	core composite	The blended sample (all of both solid phases) appeared medium brown, contained black grit, and was fairly dry.

Note:

¹Weiss, R. L. and B. M. Mauss, 1987, *Data Transmittal Package for 241-TY-106 Waste Tank Characterization*, SD-RE-TI-181, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

4.0 ANALYTICAL RESULTS

4.1 OVERVIEW

This section summarizes the analytical results from the sampling events and provides concentration and inventory estimates for measured analytes. The data used for these estimates were obtained from the 1985 and 1995 sampling events (Weise and Mauss 1987 and Jo 1995, respectively). Material has not been transferred to, or pumped from, the tank since 1977; therefore, the data obtained in 1985 are considered to be best estimates of tank contents.

The samples collected from tank 241-TY-106 in 1995 were taken and evaluated according to the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994); therefore, only thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and total alpha analyses were performed. It should be noted that flammable gas concentration was not evaluated during this analysis. Individual chemical and radiochemical constituents were evaluated at the completion of the 1985 sampling event; these results provided concentration and inventory estimates. The analytical data are shown in Table 4-1.

Table 4-1. Analytical Data Tables for Tank 241-TY-106.

Analysis	Location
Total Alpha (1995)	Table 4-2
Tank 241-TY-106 Characterization Summary	Table 4-3
Thermogravimetric Analysis (1995)	Table 4-4
Differential Scanning Calorimetry (1995)	Table 4-5
1985 Sample Results	Appendix A

4.2 DATA PRESENTATION

Table 4-2 shows the data for total alpha. The table lists the sample numbers and locations from which the samples were taken. The result column lists the value detected in the original sample in the laboratory; duplicate lists the sample's duplicate analysis value. A less than symbol (<) indicates that the analyte was noted but was below the analytical instrument's calibrated detection limit for the sample. The mean, which is a simple average of the results and their duplicates, was derived by adding all results (detected and nondetected) and dividing by the total number of sampling points. When the data were lower

than the detection limit, the detection limit value was used. This method presents conservative estimates that give high bias. This information may be obtained from the 45 day report for tank 241-TY-106 (Jo 1995).

Table 4-2. Tank 241-TY-106 Analytical Data: Total Alpha¹.

Analyte	Sample Location	Sample Number	Result	Duplicate	Mean
			$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$
Total Alpha	Riser 7	S95T000288	< 0.00415	0.0174	0.0183
	Riser 6 upper half of segment	S95T000302	0.0195	0.0218	
	Riser 6 lower half of segment	S95T000303	< 0.0198	< 0.0270	

Note:

$\mu\text{Ci/g}$ = microcuries per gram

¹Jo, J., 1995, *45-Day Safety Screening Results for Tank 241-TY-106, Auger Samples, 95-AUG-010 and 95-AUG-011*, WHC-SD-WM-DP-102, Westinghouse Hanford Company, Richland, Washington.

The best estimates regarding the chemical and radiochemical composition of the sludge in tank 241-TY-106 are listed in Table 4-3. They are derived from the two core samples taken from the tank in 1985 (Weiss et al. 1987). The data resulting from these cores (see Appendix A) were averaged. The mean concentrations appear in the table. Projected inventory values were derived for each reported analyte from its mean concentration and a waste volume of 64,300 liters as demonstrated by the following equations.

$$\text{Projected Inventory (kg)} = [\mu\text{g/g}] [1.37 \text{ g/mL}] [1000 \text{ mL/L}] [64,300 \text{ L}] [1 \text{ kg}/1\text{E}+09 \mu\text{g}]$$

$$\text{Projected Inventory (Ci)} = [\mu\text{Ci/g}] [1.37 \text{ g/mL}] [1000 \text{ mL/L}] [64,300 \text{ L}] [1 \text{ Ci}/1\text{E}+06 \mu\text{Ci}]$$

where:

Ci = curies
 g/mL = grams per milliliter
 kg = kilogram
 L = liter
 μCi = microcuries
 $\mu\text{Ci/g}$ = microcuries per gram
 μg = microgram
 $\mu\text{g/g}$ = micrograms per gram

Table 4-3. Tank 241-TY-106 Characterization Summary (2 sheets).

Analyte	Concentration	Projected Inventory
METAL	$\mu\text{g/g}$	kg
Ag	27.7	2.44
Al	6,850	603
Ba	776	68.4
Bi	525	46.2
Cd	28.5	2.51
Cr	142	12.5
Fe	45,800	4,030
Mn	554	48.8
Na	105,000	9,250
Ni	68.3	6.02
P	19,300	1,700
Pb	384	33.8
Si	89,300	7,870
U	8,250	727
Zr	648	57.1
ANIONS	$\mu\text{g/g}$	kg
Cl^-	1,510	133
F^-	< 866	< 76.3
CO_3^{2-}	1,250	110
SO_4^{2-}	17,200	1,520
Free OH^-	0.673	0.0593
NO_3^-	170,000	15,000
NO_2^-	7,030	619
CARBON	$\mu\text{g C/g}$	kg C
TOC	2,290	202
PHYSICAL PROPERTIES	g/mL	%
Density	1.37	---
% Water ¹	---	34.7

Table 4-3. Tank 241-TY-106 Characterization Summary (2 sheets).

Analyte	Concentration	Projected Inventory
RADIONUCLIDES	$\mu\text{Ci/g}$	Ci
^{241}Am	0.0486	4.28
^{14}C	1.17E-03	0.103
^{137}Cs	21.9	1,930
^{60}Co	0.0311	2.74
^{129}I	0.0665	5.86
$^{239/240}\text{Pu}$	0.0402	3.54
^{90}Sr	136	12,000
^{99}Tc	0.122	10.7
Total Beta	451	39,700

Note:

¹Jo, J., 1995, *45-Day Safety Screening Results for Tank 241-TY-106, Auger Samples, 95-AUG-010 and 95-AUG-011*, WHC-SD-WM-DP-102, Westinghouse Hanford Company, Richland, Washington.

The density of the sludge was reported as 1.37 g/mL; a calculated average of the 1985 sample results yielded this value. The waste in Tank 241-TY-106 was found to be 34.7 percent water by calculating a nonweighted mean from the 1995 TGA data.

4.3 PHYSICAL MEASUREMENTS AND THERMODYNAMIC ANALYSES

4.3.1 Thermodynamic Analyses

Thermogravimetric analysis and differential scanning calorimetry were performed on each auger sample for tank 241-TY-106. The analyses determine the thermal stability or reactivity of a material. The TGA measures the mass of a sample while the temperature of the sample is increased at a constant rate. Nitrogen is passed over the sample during heating. Any weight decrease in a sample represents a loss of gaseous matter from the sample through evaporation or through a reaction that forms gas phase products.

The moisture content is estimated by assuming that all TGA sample weight loss up to a certain temperature (in this case 120 to 144 °C) is caused by water vaporization. Moisture and other volatile matter fractions can often be differentiated by inflection points in the rate of sample weight loss. Weight loss above this temperature is attributed to the evolution of reaction product gases.

The weight percent water by TGA was performed using laboratory procedure LA-560-112, Rev. A-2 with a nitrogen purge. All results were above the safety screening notification limit of less than 17 percent water. Table 4-4 summarizes the results of the TGA performed on the tank 241-TY-106 safety screening auger samples.

In the DSC analysis, the heat flow above the usual heat capacity of the substance is measured while the substance is exposed to a linear increase in temperature. While the substance is being heated, nitrogen is passed over the waste material to remove any gases being released. The onset temperature for an endothermic or exothermic event on a DSC is determined graphically.

The DSC analyses for tank 241-TY-106 auger samples were performed using laboratory procedure LA-514-113, Rev. B-1 and a Mettler 20 Differential Scanning Calorimeter under a nitrogen purge. All results were below the safety screening notification limit of 481 joules per gram (J/g) on a dry basis.

Table 4-4. Tank 241-TY-106 Percent Water Thermogravimetric Analysis Results.

Sample	Temperature Range °C	Result	Duplicate	Mean
		% H ₂ O	% H ₂ O	% H ₂ O
Riser 7 S95T000286	Amb to 120	30.3	30.8	30.5
Riser 6 S95T000299	Amb to 127	37.2	32.2	34.7
Riser 6 S95T000299 Dup 2	Amb to 120	34.6	---	34.6
Riser 6 S95T000301	Amb to 144	39.2	39.2	39.2

Table 4-5 summarizes the DSC results for Tank 241-TY-106 auger samples. It shows two endotherms in each run for each sample (no exothermic reactions noted). The first endotherm started at the lower temperature limit of the analysis (ambient). The first transition is complete between 164 °C and 199 °C. The most probable phenomena occurring in this region are the release of the bulk and interstitial water in the sample material.

Additional endotherms were noted during the second transition between 253 °C and 313 °C. The weight losses in this range are probably attributed to the release of gaseous reaction products.

Table 4-5. Tank 241-TY-106 Differential Scanning Calorimetry Results.

Sample	Run	Transition 1		Transition 2	
		ΔH J/g	Temp. Range °C	ΔH J/g	Temp. Range °C
Riser 7 S95T000286	1	935	Amb to 174	47.3	254 to 313
	2	834	Amb to 192	22.5	276 to 308
Riser 6 S95T000299	1	802	Amb to 164	33.6	253 to 307
	2	938	Amb to 174	24.0	277 to 307
Riser 6 S95T000301	1	1,020	Amb to 188	32.2	280 to 312
	2	927	Amb to 199	28.4	279 to 312

5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

This section evaluates the overall quality and consistency of available results and assesses and compares these results against historical information and program requirements.

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

This section evaluates sampling and analysis factors that may impact data interpretation. These factors are used to assess the overall quality and consistency of data and to identify limitations in using data.

5.1.1 Field Observations

The 1995 samples varied in color from lighter shades of olive green or light brown near the top to darker shades near the bottom. The 1995 samples from riser 6 were observed to be moist and sticky, while the sample removed from riser 7 appeared drier. Evaluation of thermogravimetric analysis results found that riser 6 samples contained 13 to 29 percent more water than the riser 7 sample (see Table 4-4).

The 1985 samples varied in color from gray to light brown near the top to darker brown near the bottom, and the waste from both cores appeared to be drier near the top and more moist near the bottom. A chunky consistency and debris (a small rock) were noted in the lower layer of the waste from riser 5 (core 3), while black flecks were observed in the lower part of the waste obtained via riser 7 (core 7). The waste from core 3 showed two distinct solid phases, while that of core 7 did not. Furthermore, the density of the two 1985 cores differed (1.31 for core 3 and 1.43 for core 7). Because of the difference in density observed for the two cores, the data were compared to determine whether core 7 contained consistently higher concentrations of chemical constituents than core 3. As seen in Table 5-1, neither core has consistently higher concentrations of major analytes (for example, core 3 has higher concentrations of phosphorus, sodium, and nitrate; and core 7 has higher concentrations of aluminum, iron, and silicon).

Relative percent differences (RPDs) for analytes from the 1985 cores are also shown in Table 5-1. The RPD is a measure of variability and is defined as the absolute of one duplicate minus the other, divided by the mean. Relative percent differences for the major analytes demonstrate close agreement (that is, iron, silicon, sodium, and nitrate). However, RPDs for some other analytes are quite large (that is, aluminum, barium, and hydroxide).

Table 5-1. Concentrations and Relative Percent Differences for Cores 3 and 7¹
(2 sheets).

Analyte	Core 3 μg/g	Core 7 μg/g	Relative Percent Difference
METALS			
Al	3,090	10,600	110
Ba	1,330	221	143
Bi	803	246	106
Cd	39.8	17.2	80
Cr	206	78.5	90
Fe	39,900	51,700	26
Pb	392	375	4
Mn	499	609	20
Ni	74.9	61.6	19
P	24,900	13,700	58
Si	66,500	112,000	51
Ag	49.0	6.35	154
Na	134,000	76,800	54
U	10,500	6,000	55
Zr	863	432	67
ANIONS			
CO ₂ ³⁻	1,250	—	—
Cl ⁻	1,510	—	—
F ⁻	< 866	—	—
NO ₂ ⁻	7,030	—	—
NO ₃ ⁻	211,000	128,000	49
SO ₄ ²⁻	17,200	—	—
Free OH ⁻	1.31	0.0356	189

Table 5-1. Concentrations and Relative Percent Differences for Cores 3 and 7¹
(2 sheets).

Analyte	Core 3	Core 7	Relative Percent Difference
CARBON	$\mu\text{g C/g}$	$\mu\text{g C/g}$	
TOC	2,480	2,090	17
PHYSICAL	g/mL	g/mL	
Density	1.31	1.43	9
RADIONUCLIDES	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	
²⁴¹ Am	0.0437	0.0535	20
¹⁴ C	1.55E-03	7.95E-04	64
¹³⁷ Cs	21.5	22.3	4
⁶⁰ Co	0.0452	0.0169	91
¹²⁹ I	0.0130	0.12	161
^{239/240} Pu	0.0591	0.0212	94
⁹⁰ Sr	107	164	42
⁹⁹ Tc	0.232	0.0117	181
Total Alpha	0.196	—	—
Total Beta	315	586	61

Note:

Weiss, R. L. and B. M. Mauss, 1987, *Data Transmittal Package for 241-TY-106 Waste Tank Characterization*, SD-RE-TI-181, Rev. 0, Rockwell Hanford Operations, Richland Washington.

5.1.2 Quality Control Assessment

An attempt is always made to quantify the different sources of error possible during the chemical analysis of a sample. When these errors are summarized, they give a strong indication of data reliability. If one or more of the error estimates are outside the acceptable limits, the accuracy of the concentration estimate is in question. Possible sources of error

include sample contamination, matrix interferences, analytical method error, and poor instrument calibration. Error estimates are determined from the analysis of standards, spike recoveries, blank contamination, and sample duplicate evaluation.

Data quality control information was not provided for the 1985 sampling event; therefore, the accuracy and precision of those analytical results are unknown. The data package for the 1995 auger samples did provide some quality control information. It is discussed in the following paragraphs.

Standards used to estimate the accuracy of the analytical method are evaluated prior to and concurrent with sample analysis. Standards contain the analytes of interest at known concentrations. Standard solutions may or may not be independent of the standard used for calibration. The criterion for standard recovery is 100 ± 10 percent. If a standard is above or below the criterion, then analytical results may be biased high or low, respectively. As seen in Table 5-2, all standard recoveries for percent water, differential scanning calorimetry (DSC), and total alpha were well within the limits.

Matrix spikes are used to estimate the bias of the analytical method caused by matrix interferences. Spike samples are prepared by splitting a sample into two aliquots and adding a known amount of a particular analyte to one aliquot to calculate a percent recovery. The quality control criterion for matrix spikes is 100 ± 10 percent recovery. As with standards, if a spike is above or below the criterion, then analytical results may be biased high or low, respectively. Spikes were only conducted on total alpha; both from riser 6 were slightly below the quality control limits. This indicates that data results may be biased low. Since the total alpha sample results or detection limits were less than three orders of magnitude of the action limit, a rerun was not requested (Jo 1995).

Table 5-2. Quality Control Summary for Tank 241-TY-106.

Riser	Analyte	RPD % ¹	Standard % ²	Spike Rec. % ³
6	% Water (upper half)	14.4	99.5	na
	% Water (lower half)	0.05	100	na
	DSC (upper half)	na	102	na
	DSC (lower half)	na	104	na
	Total Alpha (upper half)	11.1	91.8	86.9
	Total Alpha (lower half)	na	91.8	86.4
7	% Water	1.64	99.5	na
	DSC	na	102	na
	Total Alpha	na	95.3	92.2

Notes: ¹10% limit.

²Range = 90-110%.

³Range = 90-110%.

DSC = differential scanning calorimetry

RPD = relative percent difference

NA = not applicable

Method blanks, which document contamination resulting from the analytical process, are prepared by filling sample containers with deionized, distilled water. They are carried through the complete sample preparation and analytical procedure, and all reagents used in the sample processing are added in the same volumes. Blanks were conducted only on the total alpha data, and none of the results were detected. This indicates that contamination was not a problem.

Random analytical error can be estimated from analytical results (variation between duplicate samples, and sample heterogeneity), which provides an indication of laboratory precision and the homogeneity of samples. To estimate this error, an RPD is calculated for each duplicate pair. The tank characterization plan for tank 241-TY-106 set the duplicate precision acceptance criterion at no RPD being larger than 10 percent (Schreiber 1995). The percent water and total alpha RPDs from the upper half of riser 6 both exceeded the quality control criterion. This violation is relatively slight, however, and should not have a large impact on data quality.

5.1.3 Data Consistency Checks

5.1.3.1 Comparison of Total Alpha and Total Beta with the Sum of Individual Isotopes. This evaluation can be used to ascertain the performance of the radiochemical separation methods or as an indicator that other isotopes may be present in significant quantities. With regard to the 1985 results from cores 3 and 7, a comparison was made between the gross beta activity and the sum of the individual beta emitters. The activities of the individual beta emitters were summed according to the following equation:

$$\text{Total Beta} = (1.42) * (2 * {}^{90}\text{Sr}) + (1.51) * {}^{137}\text{Cs}$$

The factor of 2 in the Total Beta equation accounts for the ${}^{90}\text{Y}$ daughter product and the factor of 1.42 and 1.51 accounts for 222-S Laboratory calibration to a ${}^{60}\text{Co}$ source.

A comparison was also made between gross alpha activity and the sum of individual alpha emitters. This comparison could only be made for the core 3 results because the total alpha analysis was not conducted on core 7. The activities of the individual alpha emitters from core 3 were summed as follows:

$$\text{Total Alpha} = {}^{241}\text{Am} + {}^{239/240}\text{Pu}$$

The comparisons (see Tables 5-3 and 5-4) are based on results given in Weiss and Mauss (1987). The relative percent differences ranged from 6.75 percent to 62.2 percent and do not seem unreasonable given the variables involved in the analysis.

Table 5-3. Comparison of Total Beta Activity with the Total of the Individual Activities.

Analyte	Half-Life	Core 3 ($\mu\text{Ci/g}$)	Core 7 ($\mu\text{Ci/g}$)
^{90}Sr	28.6 year	304	466
^{137}Cs	30.17 year	32.5	33.7
Sum of Beta Emitters (a)	---	337	500
Total Beta Result (b)	---	315	586
Relative Percent Difference ¹	---	6.75	15.8

Notes:

 $\mu\text{Ci/g}$ = microcuries per gram¹Relative percent difference is defined as the absolute difference of a and b, divided by their average.

Table 5-4. Comparison of Total Alpha Activity with the Total of the Individual Activities.

Analyte	Half-Life	Core 3 $\mu\text{Ci/g}$
^{241}Am	458y	0.0437
^{239}Pu	24,400y	0.0591
Sum of Alpha Emitters (a)	---	0.103
Total Alpha (b)	---	0.196
Relative Percent Difference ¹	---	62.2%

Note:

¹Relative Percent Difference is defined as the absolute difference of a and b, divided by their average.

5.1.3.2 Mass and Charge Balance. The principle objective in performing a mass and charge balance is to determine if measurements are consistent. In calculating the balance, only the data from core 3 (sample # 111C) of the 1985 sampling event were considered because it was the only core with extensive anion data available. Therefore, this consistency check is applicable only to the core 3 analytes in Appendix A and only those which were detected at a concentration of 7,000 micrograms per gram ($\mu\text{g/g}$) or greater.

With the exception of sodium, all cations listed in Table 5-5 were assumed to be present in their most common hydroxide or oxide forms, and the concentrations of the assumed species were calculated stoichiometrically. There may be some argument about whether certain species are hydroxides or oxides, but the difference in molecular weight has a minimal effect on the overall mass balance. Although smaller concentrations of other forms of the species are probably present in the waste, they are not included in order to keep the mass-charge balance calculations simple and consistent.

Because precipitates are neutral species, all positive charge was attributed to the sodium cation. All anions listed in Table 5-6 were assumed to be present as soluble or insoluble sodium salts and expected to balance the positive charge. Because no phosphate value was calculated directly for core 3, the total phosphate given was calculated from the Inductive Coupled Plasma (ICP) phosphorus result of 24,900 $\mu\text{g/g}$ and yielded a value of 76,300 $\mu\text{g/g}$. It was expected that most phosphate is present as an insoluble species.

The concentrations of the assumed species in Table 5-5, the anionic species in Table 5-6, and the percent water were used to calculate the mass balance. The mass balance was calculated from the formula below. The factor 0.0001 is the conversion factor from $\mu\text{g/g}$ to weight percent.

$$\begin{aligned} \text{Mass balance} &= \% \text{ Water} + 0.0001 \times \{\text{Total Analyte Concentration}\} \\ &= \% \text{ Water} + 0.0001 \times \{\text{FeO(OH)} + \text{SiO}_2 + \text{Na}^+ + \text{U}_3\text{O}_8 + \text{NO}_3^- + \text{NO}_2^- \\ &\quad + \text{PO}_4^{3-} + \text{SO}_4^{2-}\} \end{aligned}$$

The total analyte concentrations calculated from the above equation was 663,000 $\mu\text{g/g}$. The mean weight percent water obtained from thermogravimetric analysis reported in Section 4.2 is 34.8. This value was derived from the 1995 auger sample results; percent water was not calculated in the 1985 sampling event. The mass balance obtained from adding the percent water to the total analyte concentration is 101 percent (see Table 5-7). A perfect mass balance would have yielded a balance of 100 percent.

The charge balance is the ratio of total cations (microequivalents) to total anions (microequivalents) with respect to the species listed below, which were assumed to be water soluble.

$$\text{Total cations (microequivalents)} = \text{Na}^+ / 23.0$$

The total cation charge, 5,830 micromole per gram ($\mu\text{mol/g}$), is calculated in Table 5-5.

$$\text{Total anions (microequivalents)}$$

$$= \text{NO}_3^- / 62.0 + \text{NO}_2^- / 46.0 + \text{PO}_4^{3-} / 31.7 + \text{SO}_4^{2-} / 48.0$$

The total anion charge, 6,320 $\mu\text{mol/g}$, is calculated in Table 5-6.

Table 5-5. Cation Mass and Charge Data.

Analyte	Concentration ($\mu\text{g/g}$)	Assumed Species	Concentration of Assumed Species ($\mu\text{g/g}$)	Charge ($\mu\text{mol/g}$)
Iron	39,900	$\text{FeO}(\text{OH})$	62,300	0
Silicon	66,500	SiO_2	142,000	0
Sodium	134,000	Na^+	134,000	5,830
Uranium	10,500	U_3O_8	12,400	0
Totals			351,000	5,830

Notes:

$\mu\text{g/g}$ = micrograms per gram
 $\mu\text{mole/g}$ = micromole per gram

Table 5-6. Anion Mass and Charge Data.

Analyte	Concentration ($\mu\text{g/g}$)	Charge ($\mu\text{mol/g}$)
Nitrate	211,000	3,400
Nitrite	7,030	153
Phosphate	76,300 ¹	2,410
Sulfate	17,200	358
Totals	312,000	6,320

Notes:

$\mu\text{g/g}$ = micrograms per gram
 $\mu\text{mole/g}$ = micromoles per gram

¹The phosphate value of 76,300 was derived from the ICP phosphorus value of 24,900.

Table 5-7. Mass Balance Totals.

	Concentrations $\mu\text{g/g}$
Total from Table 5-5	351,000
Total from Table 5-6	312,000
Water	348,000
Grand Total	1,010,000

The ratio of total cation microequivalents to total anion microequivalents (+/-) was 0.92; a perfect charge balance would yield a ratio of 1.00.

The mass and charge balance results (101 percent and 0.92, respectively) demonstrate agreement among the core 3 analyses when considering the uncertainty in the assumptions and the few measurements used to derive these values. The results do not indicate the presence of large data inconsistencies or errors, and there is no indication that major components were missing from the list of evaluated analytes.

5.2 COMPARISON OF DATA SOURCES

5.2.1 Comparison of 1995 and 1985 Data

Total alpha is the only analyte for which a comparison can be made between data sets. Because the waste composition of the tank did not change due to transfer activities between sampling events, a comparison should be possible. The total alpha result for 1985 was $0.196 \mu\text{Ci/g}$ (Weiss and Mauss 1987), and the total alpha result from the 1995 data was $0.0183 \mu\text{Ci/g}$ (Jo 1995), a factor of ten difference. If it is assumed that the major contributors to total alpha activity are ^{239}Pu and ^{240}Pu , of which ^{240}Pu has the shortest half-life (6,570 years), then it is evident that the difference in the results is caused by something other than radioactive decay. A possible source of the difference is the degree to which the samples were representative of the waste, that is, sample location.

5.2.2 Comparison of 1985 Data to the Historical Tank Content Estimates

Analyses which compare the 1985 analyses (Weiss and Mauss 1987) and the historical tank content estimates (Brevick, Gaddis, and Johnson 1995) are listed in Table 5-8. The table

demonstrates that there is good agreement ($RPD < 75$ percent) among the following constituents: chromium, iron, sodium, chloride, and nitrate.

If phosphorus detected by the 1985 analyses is assumed to be present as phosphate, the phosphate concentration is calculated to be $76,300 \mu\text{g/g}$ as previously discussed in Section 5.1.3.2. The historical tank content estimate for phosphate is $6,240 \mu\text{g/g}$, approximately an order of magnitude less than the analytical value.

Table 5-8. Comparison Between 1985 Data and the Historical Tank Content Estimate for Major Analytes.

Analyte	Average Concentration from 1985 Data	Historical Tank Content Estimate ¹	Relative Percent Difference ²
METALS	($\mu\text{g/g}$)	($\mu\text{g/g}$)	%
Cr	142	210	38.6
Fe	45,800	95,600	70.4
Na	105,000	74,900	33.5
Ni	68.3	3,320	192
U	8,250	23,400	95.7
ANIONS	($\mu\text{g/g}$)	($\mu\text{g/g}$)	%
CO_3^{2-}	1,250	12,800	164
Cl^-	1,510	1,860	20.8
NO_3^-	170,000	90,200	61.3
SO_4^{2-}	17,200	66,100	117
RADIONUCLIDES	($\mu\text{Ci/g}$)	($\mu\text{Ci/g}$)	%
^{137}Cs	21.9	0.639	189
^{90}Sr	136	3.47	190

Notes:

$\mu\text{Ci/g}$ = microcuries per gram

$\mu\text{g/g}$ = micrograms per gram

¹Brevick, C. H., L. A. Gaddis, and L. A. Johnson, 1995, *Historical Tank Content Estimate for the Northwest Quadrant of the Hanford 200 West Areas*, ICF Kaiser Hanford Company, WHC-SD-WM-ER-351, ICF Kaiser Hanford Company, Richland, Washington.

²RPD = the absolute value of column 2 minus column 3, divided by the mean of the two, times 100.

5.3 TANK WASTE INVENTORY PROFILE

With reference to the two core samples taken in 1985, no vertical subsegments were formed for chemical analysis; therefore, no statements on the vertical disposition of the waste based on chemical analyses can be made (see Section 2.0). However, a layer of diatomaceous earth is known to rest on top of the uranium recovery waste in the tank, indicating that there are at least two horizontal layers in the tank. Because diatomaceous earth is primarily SiO_2 , the silicon detected by the laboratory analyses is expected to be concentrated towards the waste surface. It was also observed that waste appeared drier near the top of the samples, which would be consistent with the absorbing affects of the diatomaceous earth. Color variations were observed between the top and bottom of both cores, and core 3 showed two distinct phases although core 7 did not.

The chemical constituents of the two cores were compared in Table 5-1 to discover whether core 7 had consistently higher analyte concentrations than core 3. The results were mixed implying that no clear trend of horizontal variation was apparent.

With reference to the two auger samples taken in 1995, a statistical procedure known as the analysis of variance (ANOVA) was conducted on the percent water data to determine whether there were differences in the water concentration between the two risers or between the vertically oriented subsamples taken from the riser 6 auger sample. Tests were not conducted on the DSC or total alpha results because of nondetect values (Jo 1995). The ANOVA generates a p-value which is compared with a standard significance level ($\alpha = 0.05$). If a p-value is below 0.05, there is sufficient evidence to conclude that the sample means are significantly different from each other. However, if a p-value is above 0.05, there is not sufficient evidence to conclude that the samples are significantly different.

Three separate ANOVA tests were conducted: the first two were to determine the difference in percent water between the two risers (horizontal variation), and the third was to determine the difference between the upper and lower half of riser 6 (vertical variability). The first ANOVA test for percent water compared the entire sample from riser 7 (flutes 17 to 20) with the entire sample obtained from riser 6 (flutes 11 to 19). The results indicated that at the 0.05 level, there was no significant difference between the two risers (p-value = 0.061). The second ANOVA test compared the sample from riser 7 with the lower half of the sample obtained from riser 6. This would seem to be more fair because the bias inherent in combining the upper flutes of riser 6 was eliminated. As previously discussed in Chapter 3.0, waste from riser 7 was only recovered from auger flutes 17 to 19. The waste from the lower half of the auger sample taken from riser 6 was recovered from flutes 14 to 19. The results of the second test between the two risers indicated that, at the 0.05 level, there was a significant difference in percent water (p-value = 0.019). The results of the third ANOVA test indicated that, at the 0.05 level, there was no difference between the upper and lower halves of riser 6 (p-value = 0.322). These results should be strongly qualified in that the tank characterization plan (Schreiber 1995) called for the sampling to take place from two widely spaced risers, whereas risers 6 and 7 are only 10 feet apart.

Also, the number of samples available for the statistical analysis was very small. Nevertheless, the ANOVA test results indicate that the distribution of water in the tank appears to be fairly homogeneous vertically, but it may be heterogeneous in the horizontal direction.

The water content of the 1995 auger samples, based upon field observations, were compared to the results of the statistical analysis to determine whether they were consistent with each other. Overall, the sample from riser 6 was very moist and runny with a soft paste-like consistency. The sample from riser 7 was described as very sticky with a paste-like consistency, although some of the sample was drier and not as sticky (Jo 1995). The mean concentration estimate for the combined upper and lower portions of riser 6 was 36.9 percent, which was higher than that for riser 7 (30.5 percent). This is consistent with the description given above and tends to substantiate the statistical analysis results.

5.4 COMPARISON OF ANALYTICAL DATA AND TRANSFER HISTORY INFORMATION

The relatively large concentration of silicon found in the analytical results is expected because of the addition of diatomaceous earth to the tank in the 1970s. However, the analytical results are somewhat mixed when compared to the uranium recovery sludge estimates (see Table 2-2). The 1985 results for sodium, carbonate, and ^{90}Sr are relatively consistent with the predictions for uranium recovery sludge. Although the iron result was higher in relation to the other metals, the concentration was not as high as estimated in Table 2-2. According to the 1985 analyses, the concentrations of uranium, hydroxide, and sulfate were also overestimated by the predicted uranium recovery sludge composition (see Table 2-2 and Appendix A). The analytical results for nitrate and cesium were greater than predicted from the uranium recovery sludge estimates.

5.5 EVALUATION OF PROGRAM REQUIREMENTS

Tank 241-TY-106 is classified as a non-Watch List tank; therefore, only the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994) is applicable to this tank. This section details those data needs and determines whether the tank has been appropriately categorized concerning safety issues. The data quality objective establishes decision criteria or notification limits for concentrations of analytes of concern. The decision criteria are used to determine whether a tank is safe or whether further safety investigation is warranted. If results from one of the primary analyses exceed any decision criteria, the tank is classified "not safe," and further analyses are conducted to assure tank safety.

5.5.1 Safety Evaluation

The waste fuel energy value was determined by differential scanning calorimetry (DSC). DSC analyses were performed on the 1995 auger samples; no exotherms were observed. The total organic carbon (TOC) associated with the waste is also an indication of waste fuel content. The TOC concentration, derived from the 1985 samples, was reported to be 2,290 $\mu\text{g C/g}$ which is approximately 0.2% wet weight or 0.4% dry weight. These figures are well below the 5% TOC (dry weight) criteria established by the organic safety program (Babad et al. 1994).

Large amounts of moisture reduce the potential for propagating exothermic reactions in the waste. The thermogravimetric analyses performed on the 1995 auger samples demonstrated that the waste is 34.7 percent water by weight. The historical tank content estimate (Brevick et al. 1995) for weight percent water was 55.5 percent. These values are well above the 17 percent criteria identified in the *Tank Safety Screening Data Quality Objective*.

Another factor in assessing the safety of tank waste is its heat generation and temperature. Heat is generated in tanks primarily from radioactive decay. Because specific radionuclides were not analyzed in the 1995 sampling, the results from the 1985 sampling are examined. The primary contributors for tank 241-TY-106 are ^{90}Sr and ^{137}Cs . The estimated heat generated from the isotopes in the tank is 306 Btu/hr (89.8 watts) as shown in Table 5-9. This is well below the 40,000 Btu/hr criteria for distinguishing a high-heat from a low-heat load tank (Hanlon 1995). The recorded tank temperatures from June 1975 to January 1995 ranged from 12.2 °C to 30.0 °C with an average of 18.7 °C.

Table 5-9. Tank 241-TY-106 Projected Heat Load.

Radionuclide	Ci	Watts
^{241}Am	4.28	0.140
^{137}Cs	1,930	9.11
^{60}Co	2.74	0.0422
^{129}I	5.86	0.00274
$^{239/240}\text{Pu}$	3.54	0.108
^{90}Sr	12,000	80.4
^{99}Tc	10.7	0.00536
Total Watts		89.8

The potential for criticality can be assessed from total alpha data. The average total alpha activity in the tank based on 1995 data was estimated at 0.0183 $\mu\text{Ci/g}$, with the highest possible value being 0.0270 $\mu\text{Ci/g}$. The result from the 1985 sampling was 0.196 $\mu\text{Ci/g}$. These are approximately 200 to 2,000 times below the level of concern and the established criteria of 1 grams per liter (g/L) specified in the *Tank Safety Screening Data Quality Objective*. Using the equation below and the 1985 density result of 1.37 g/ml, the 1 g/L criteria translates into 45 $\mu\text{Ci/g}$.

$$\left(\frac{1 \text{ g}}{\text{L}}\right) \left(\frac{1 \text{ L}}{10^3 \text{ mL}}\right) \left(\frac{1 \text{ mL}}{\text{density g}}\right) \left(\frac{0.0615 \text{ Ci}}{1 \text{ g}}\right) \left(\frac{10^6 \mu\text{Ci}}{1 \text{ Ci}}\right) = \frac{61.5 \mu\text{Ci}}{\text{density g}}$$

The flammability of the gas in the tank head space of the tank is another safety screening consideration. Analysis of the tank head space was not conducted and is outside the scope of this report.

5.5.2 Operational Evaluation

The tank was sampled to evaluate safety concerns and to confirm its non-Watch List status. There are currently no liquids in the tank, and because it is an assumed leaker, liquid waste will not be transferred into it in the future. Therefore, waste compatibility issues do not apply to this tank.

5.5.3 Environmental Evaluation

Tank 241-TY-106 was not characterized to evaluate environmental compliance issues. No specific organic (volatile or semi-volatile) analyses have been performed on the tank; therefore, no environmental assessment of these compounds can be made.

The 1985 analysis did indicate that the waste contained high concentrations of environmentally sensitive metals such as cadmium, chromium, and lead. However, the metals are in an immobile precipitate and are unlikely to migrate in their present state.

5.5.4 Process Development Evaluation

The metal and anion analysis of waste from the 1985 sampling is important for evaluating the disposal waste form (glass) formulations and identifying potential components that may affect the treatment and disposal process. Because waste sludges may be blended, washed, and treated before disposal, there are no specific criteria for the parameters measured. Extensive rheological analyses have yet to be conducted on the waste. The only information on rheology available from the 1985 sampling event indicates that the viscosity of the waste is > 10,000 centipoise (cP) (Weiss and Mauss 1987). When evaluations are performed, the results will assist retrieval and pretreatment programs to determine equipment needs.

The metal analyses information for the water-digested solids yields solubility information that may be useful in the retrieving tank waste. The solubility of several metals and radionuclides was examined by comparing the water-digested results with total concentration results (see Section 3.2.2). Tables 5-10 and 5-11 list the percent solubility for several analytes from core 3 and core 7, respectively. Only those analytes detected in the leachate resulting from the water digestion were considered.

The data demonstrate that sodium and ^{99}Tc are relatively soluble species and that approximately 73 to 77 percent of the sodium and 38 to 89 percent of the ^{99}Tc will dissolve in an aqueous medium. Phosphorus and ^{137}Cs display limited solubility. About 17 to 24 percent of the phosphorus in the tank will enter solution as the phosphate ion or one of its hydrogenated derivations depending upon the pH. The solubility of ^{137}Cs is expected to approach that of sodium, but the data indicate otherwise.

The remaining metals and ^{90}Sr are relatively insoluble. With respect to chromium, these observations indicate that chromium is present as the Cr(III) species rather than the soluble Cr(VI) species.

Table 5-10. Percent Water Solubility for Core 3 Analytes.

Analyte	Water Digestion	Total Analyte Concentration	Percent Soluble
METALS	$\mu\text{g/g}$	$\mu\text{g/g}$	%
Barium	15.3	1,330	1.2
Chromium	1.64	206	0.80
Iron	8.13	39,900	0.02
Phosphorus	6,050	24,900	24
Silicon	67.5	66,500	0.10
Sodium	103,000	134,000	77
Uranium	5.05	10,500	0.05
RADIONUCLIDES	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	%
^{137}Cs	4.69	21.5	22
^{90}Sr	0.0415	107	0.04
^{99}Tc	0.206	0.232	89

Table 5-11. Percent Water Solubility for Core 7 Analytes.

Analyte	Water Digestion	Total Analyte Concentration	Percent Soluble
METALS	$\mu\text{g/g}$	$\mu\text{g/g}$	%
Barium	0.457	221	0.21
Chromium	1.37	78.5	1.7
Phosphorus	2,320	13,700	17
Silicon	44.3	112,000	0.04
Sodium	56,200	76,800	73
RADIONUCLIDES	$\mu\text{Ci/g}$	$\mu\text{Ci/g}$	%
^{137}Cs	1.57	22.3	7.0
^{90}Sr	0.0734	164	0.04
^{99}Tc	0.00443	0.0117	38

6.0 CONCLUSIONS AND RECOMMENDATIONS

The sludge in tank 241-TY-106 was sampled and analyzed in 1985 and 1995. The 1985 samples were evaluated for a broad spectrum of analytes that included metals, anions, radionuclides, density, and total organic carbon. Because the tank contents have not appreciably changed since the late 1970s, the data are considered to be best estimates of the composition of the sludge.

The 1995 sampling event was governed by the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994), and only thermogravimetric analysis, differential scanning calorimetry, and total alpha analyses were performed on the acquired samples. The results demonstrated that the tank waste satisfies the safety criteria for water content, fuel energy (heat), and criticality. It should be noted that flammable gas concentration was not evaluated during this analysis.

The sludge contains large quantities of iron, sodium, silicon, uranium, and nitrate which is expected because the material consists almost entirely of uranium recovery waste and diatomaceous earth. However, some of the proportion of the analytes does not agree as closely with history as others indicating possibility of process changes, upsets or commingling with other wastes. Environmentally sensitive metals such as cadmium, chromium, and lead are present within the waste but are unlikely to migrate in their precipitated state. The major radionuclides are ^{137}Cs and ^{90}Sr , and the heat generated by these isotopes is well below the 40,000 Btu/hr limit for the tank.

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7.0 REFERENCES

- Agnew, S. F., 1995, *Hanford Defined Wastes: Chemical and Radionuclide Compositions*, LA-UR-94-2657, Rev. .5, Los Alamos National Laboratory, Los Alamos, New Mexico.
- Agnew, S. F., P. Baca, R. Corbin, T. Duran, and K. Jurgensen, 1994, *Waste Status and Transaction Record Summary for the Northwest Quadrant*, WHC-SD-WM-TI-699, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Babad, H. and K. S. Redus, 1994, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Babad, H., S. M. Blacker, and K. S. Redus, 1994, *Data Quality Objective to Support Resolution of the Organic Fuel Rich Tank Safety Issue*, WHC-SD-WM-DQO-006, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Bergmann, L. M., 1991, *Single-Shell Tank Isolation Safety Analysis Report*, WHC-SD-WM-SAR-006, Rev. 2, Westinghouse Hanford Company, Richland, Washington.
- Brevick, C. H., L. A. Gaddis, and L. A. Johnson, 1995, *Historical Tank Content Estimate for the Northwest Quadrant of the Hanford 200 West Areas*, ICF Kaiser Hanford Company, WHC-SD-WM-ER-351, ICF Kaiser Hanford Company, Richland, Washington.
- De Lorenzo, D. S., A. T. DiCenso, D. B. Hiller, K. W. Johnson, J. H. Rutherford, B. C. Simpson, and D. J. Smith, 1994, *Tank Characterization Reference Guide*, WHC-SD-WM-TI-648, Westinghouse Hanford Company, Richland, Washington.
- Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, U.S. Department of Energy, Olympia, Washington.
- Hanlon, B. L., 1995, *Waste Tank Summary for Month Ending January 31, 1995*, WHC-EP7-0182-82, Westinghouse Hanford Company, Richland, Washington.
- Jo, J., 1995, *45-Day Safety Screening Results for Tank 241-TY-106, Auger Samples, 95-AUG-010 and 95-AUG-011*, WHC-SD-WM-DP-102, Westinghouse Hanford Company, Richland, Washington.

- Johnson, M. G., 1995, *Technical Bases for Leak Detection Surveillance of Waste Storage Tanks*, WHC-SD-WM-TI-573, Westinghouse Hanford Company, Richland, Washington.
- Jungfleisch, F. M., 1984, *TRAC: Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, SD-WM-TI-057, Rockwell Hanford Operations, Richland, Washington.
- Scaief III, C. C., 1991, *Temperature Measurement Error Analysis*, WHC-SD-WM-TI-483, Westinghouse Hanford Company, Richland, Washington.
- Schreiber, R., 1995, *Tank 241-TY-106 Tank Characterization Plan*, WHC-SD-WM-TP-312, Westinghouse Hanford Company, Richland, Washington.
- Tran, T. T., 1993, *Thermocouple Status Single-Shell and Double-Shell Waste Tanks*, WHC-SD-WM-TI-533, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Weiss, R. L., 1986, *TY Tank Farm Waste Characterization Data*, RHO-WM-TI-1 P, Rockwell Hanford Operations, Richland, Washington.
- Weiss, R. L. and B. M. Mauss, 1987, *Data Transmittal Package for 241-TY-106 Waste Tank Characterization*, SD-RE-TI-181, Rev. 0, Rockwell Hanford Operations, Richland Washington.
- Welty, R. K., 1988, *Waste Storage Tank Status and Leak Detection Criteria*, WHC-SD-WM-TI-356, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Hanford Site Tank Farm Facilities Interim Safety Basis*, WHC-SD-WM-ISB-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

1985 CORE SAMPLE RESULTS

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Table A-1. 1985 Sample Data for Tank 241-TY-106 (Weiss 1987) (2 sheets).

Analyte	Core 3 Sample 111C Riser 5 ($\mu\text{g/g}$)	Core 7 Sample 161C Riser 7 ($\mu\text{g/g}$)	Average Concentration ($\mu\text{g/g}$)	Projected Inventory (kg)
METALS				
Al	3,090	10,600	6,850	603
Ba	1,330	221	776	68.4
Bi	803	246	525	46.2
Cd	39.8	17.2	28.5	2.51
Cr	206	78.5	142	12.5
Fe	39,900	51,700	45,800	4,030
Pb	392	375	384	33.8
Mn	499	609	554	48.8
Ni	74.9	61.6	68.3	6.02
P	24,900	13,700	19,300	1,700
Si	66,500	112,000	89,300	7,870
Ag	49.0	6.35	27.7	2.44
Na	134,000	76,800	105,000	9,250
U	10,500	6,000	8,250	727
Zr	863	432	648	57.1
ANIONS				
CO_3^{2-}	1,250	---	1,250	110
Cl^-	1,510	---	1,510	133
F^-	< 866	---	< 866	< 76.3
NO_2^-	7,030	---	7,030	619
NO_3^-	211,000	128,000	170,000	15,000
SO_4^{2-}	17,200	---	17,200	1,520
Free OH^-	1.31	0.0356	0.673	0.0593
CARBON	$\mu\text{g C/g}$	$\mu\text{g C/g}$	$\mu\text{g C/g}$	kg C
TOC	2,480	2,090	2,290	202
PHYSICAL	g/mL	g/mL	g/mL	
Density	1.31	1.43	1.37	---

Table A-1. 1985 Sample Data for Tank 241-TY-106 (Weiss 1987) (2 sheets).

Analyte	Core 3 Sample 111C Riser 5 ($\mu\text{g/g}$)	Core 7 Sample 161C Riser 7 ($\mu\text{g/g}$)	Average Concentration ($\mu\text{g/g}$)	Projected Inventory (kg)
RADIONUCLIDES	($\mu\text{Ci/g}$)	($\mu\text{Ci/g}$)	($\mu\text{Ci/g}$)	(Ci)
^{241}Am	0.0437	0.0535	0.0486	4.28
^{14}C	1.55E-03	7.95E-04	1.17E-03	0.103
^{137}Cs	21.5	22.3	21.9	1,930
^{60}Co	0.0452	0.0169	0.0311	2.74
^{129}I	0.0130	0.120	0.0665	5.86
$^{239/240}\text{Pu}$	0.0591	0.0212	0.0402	3.54
^{90}Sr	107	164	136	12,000
^{99}Tc	0.232	0.0117	0.122	10.7
Total Alpha	0.196	---	0.196	17.3
Total Beta	315	586	451	39,700

Notes:

$\mu\text{g/g}$ = micrograms per gram
 kg = kilograms
 $\mu\text{g C/g}$ = micrograms of carbon per gram
 g/mL = grams per milliliter
 $\mu\text{Ci/g}$ = microcuries per gram
 C = carbon
 Ci = curies

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